Attention and Somatic Awareness in Physical Symptom Reporting and Health Anxiety: Implications for Medically Unexplained Symptoms

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Abstract

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The aim of the work presented in this thesis, was to investigate two general hypotheses derived from theories of the development and maintenance of medically unexplained symptoms (MUS) and health anxiety; that individual differences in attention to the body and somatic awareness contribute to the experience of physical symptoms and health anxiety.

Three studies (an analogue pilot study, a prospective cohort study with primary care patients, and an analogue study involving a negative mood induction) were conducted to investigate the relationship between attention, somatic awareness, symptom reporting and health anxiety.

In the pilot study, enhanced attentional disengagement from neutral material was associated with health anxiety and delayed disengagement from neutral material was associated with symptom reporting. In the primary care study, enhanced disengagement from neutral body-irrelevant material and delayed disengagement from threatening body-relevant material were independently associated with health care utilisation, but not symptom reporting or health anxiety. However, the longitudinal analysis revealed that attentional disengagement was neither a predictor of, or predicted by, health care utilisation. The tendency to experience distortions in somatic awareness was independently associated with symptom reporting, health anxiety and health care utilisation. Longitudinal analysis revealed that symptom reporting and health anxiety were independent predictors of somatic distortion, but that somatic distortion was not a predictor of symptom reporting or health anxiety. The results of a structural equation modeling analysis suggest that a model including both attentional disengagement and the tendency to experience distortions in somatic awareness improves understanding of symptom reporting, health anxiety and health care utilisation. In the negative mood induction study, however, neither attentional disengagement nor the tendency to experience distortions in somatic awareness were significantly associated with symptom reporting or health anxiety.

The evidence presented here suggests that complex attentional processes may be associated with health seeking behaviours, possibly via a third unknown variable. This evidence, however, does not support the often-hypothesised general attentional bias for the body as a causative factor in the development of health anxiety or symptom reporting. This research has provided important evidence about attentional differences and how future research might extend the findings reported here. Furthermore, the findings regarding the tendency to experience distortions in somatic awareness provides empirical support for theories that suggest MUS may be associated with a tendency to place greater weight on top-down factors in the creation of somatic awareness (Brown, 2004; Edwards et al., 2013). However, whilst alterations in somatic awareness may be a maintenance factor for symptom reporting and health anxiety, somatic distortion may not be a causative factor in their development.

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Research presentations

The research reported in this thesis has led to the following conference presentations:

Based on Chapters 4 and 5:

Philip Milner, Anna Chapman & Richard Brown (2013). Poster (presented by Philip Milner): Are metacognitions associated with physical symptom reporting, health preoccupation, distress and illness behaviours? Second International Conference of Metacognitive Therapy, convened in Manchester, April, 2013.

Anna Chapman, Richard J. Brown, Carolyn Chew-Graham, Richard Emsley & Ellen Poliakoff (2013). Talk (Presented by Anna Chapman): A tendency to experience distortions in somatosensory awareness correlates with physical symptom reporting in primary care patients. Inaugural Conference of the European Association of Psychosomatic Medicine, convened at the University of Cambridge, July 2013.

Richard J. Brown, Anna Chapman, Carolyn Chew-Graham, Richard Emsley & Ellen Poliakoff (2013). Talk (Presented by Richard J. Brown): Physical symptom reporting may be associated with a general deficit in attention rather than excessive body-focus. Inaugural Conference of the European Association of Psychosomatic Medicine, convened at the University of Cambridge, July 2013.

List of abbreviations

CFS	Chronic Fatigue Syndrome
CBT	Cognitive Behavioural Therapy
DSM	Diagnostic and Statistical Manual of Mental Disorders
ECG	Electrocardiogram
EEG	Electroencephalogram
EHI	Edinburgh Handedness Inventory
ERP	Evoked Response Potentials
FMRI	Functional Magnetic Resonance Imaging
FMS	Fibromyalgia Syndrome
HBP	Heart Beat Perception
ICD	International Classification of Diseases
IBS	Irritable Bowel Syndrome
IE	Inverse Efficiency
IOR	Inhibition Of Return
LED	Light Emitting Diode
MUS	Medically Unexplained Symptoms
MSE	Modality Shift Effect
NA	Negative Affectivity
PHQ	Patient Health Questionnaire
S.D	Standard Deviation
SDQ	Somatoform Dissociation Questionnaire
SDT	Signal Detection Theory
SFD	Somatoform Disorder
SOA	Stimulus Onset Asynchrony
SSAS	Somatosensory Amplification Scale
SSDT	Somatic Signal Detection Task
STAI	State Trait Anxiety Inventory
TOJ	Temporal Order Judgement

Chapter 1. General introduction – Medically unexplained symptoms, physical symptom reporting and health anxiety: conceptualisation, diagnoses, and causation

The aim of the research presented here was to investigate hypotheses derived from psychological theories of the development and maintenance of medically unexplained symptoms (MUS). The general hypothesis was that individual differences in attentional processes and somatic awareness contribute to the tendency to report physical symptoms and health anxiety. This thesis also explored the relationship between attentional processes and somatic awareness.

In the current chapter, Section 1.1 introduces physical sensations and symptoms. Section 1.2 introduces the concept of physical symptom reporting and MUS, as well as their diagnosis and treatment. Section 1.3 considers how the concept of MUS has been operationalised in research. Section 1.4 considers factors associated with the experience of physical symptom reporting and MUS. Section 1.5 considers the results of longitudinal and treatment studies. Section 1.6 describes theories of MUS and symptom perception. On the basis of these theories two areas of research are identified - attention and somatic awareness- which form the basis of this thesis. Both areas of research are introduced in greater detail in Chapter 2.

1.1. Physical sensations

Physical sensations are thought to provide information about the body's condition, including emotional states, homeostatic processes and disease or injury. Sensations are related to our most pedestrian behaviours, and are often both the cause and effect of those behaviours. They initiate activity and then signal when activity has occurred (e.g., a pang of hunger initiates food-seeking, which leads to eating, which leads to a sensation of satiety signalling that eating should cease). Consequently, perceiving sensations and initiating appropriate behaviours in response to them is a highly adaptive process that is of paramount importance for survival.

1.1.1. *When is a sensation a symptom?*

Symptom perception is not based simply on the detection of somatosensory sensations. A sensation becomes a symptom only when somatosensory information is perceived to be physically or psychologically deleterious and is interpreted by the

individual as inferring disease or injury. Generally, symptoms are considered to be either unpleasant or unexpected somatic sensations, for example, headache or fatigue. Most symptoms are an entirely private and therefore subjective experience. O*bservable* changes (either by the individual experiencing them or others) in the body, such as skin rashes or changes in blood pressure, are referred to as 'signs' and may be objective markers of disease. Signs, like sensations, may only become symptoms if somatosensory information is perceived, and then interpreted, as being physically or psychologically deleterious.

1.2. Symptom reporting and medically unexplained symptoms

Disease refers to pathological changes in normal physiological functioning, not resulting from physical injury. Although disease and illness are terms that are often used interchangeably, illness refers more specifically to an individual's personal experience of symptoms. Disease can exist in the *absence* of symptoms (e.g. hypertension) and, similarly, symptoms can exist in the absence of disease. Symptoms for which an adequate medical explanation cannot be found are ubiquitous in health care settings and are known as medically unexplained symptoms (MUS; Mayou, 1993). The relationship between symptomology and disease is variable, and the association between subjective symptom reports and objective markers of health is modest at best (Pennebaker, 1982; Watson & Pennebaker, 1989).

In primary care, 10-20% of patients report symptoms that are considered by their doctors to be unexplained by physical disease (Mumford, Devereux, Maddy, & Johnston, 1991; Peveler, Kilkenny, & Kinmouth, 1997; van der Weijden, van Velsen, Dinant, van Hasselt, & Grol, 2003). In secondary care, this figure rises to around 30-70% of patients (Nimnuan, Rabe-Hesketh, Wessely, & Hotopf, 2001; Reid et al., 2001). For many, MUS are a transitory experience; for some, however, the experience can become chronic and extremely distressing. Many patients experiencing MUS consult their doctors frequently and health care costs are disproportionately high in this group (Smith, Monson, & Ray, 1986; Barsky, Orav, & Bates, 2005). The estimated annual cost of MUS in the UK for working-age patients is estimated at £18 billion (Bermingham, Cohen, Hague, & Parsonage, 2010), which is greater than the annual cost of dementia for all ages (Knapp & Prince, 2007).

The quality of life of patients with chronic MUS can be as poor as those with chronic medically *explained* symptoms (i.e., those with a demonstrable medical cause;

Smith et al., 1986). In fact, the greater the number of reported symptoms the more disabled a patient is likely to be (Katon, Lin, Vonn Korff, Russo, Lipscomb, & Bush, 1991), irrespective of whether their symptoms have a medical explanation (Barsky et al., 2005; Jackson, Fiddler, Kapur, Wells, Tomenson, & Creed, 2006; Ladwig, Marten-Mittag, Lacruz, Henningsen & Creed, 2010). Thus, high symptom reporting, whether associated with medical disease or otherwise, presents a significant challenge to patients and healthcare services alike (Creed, et al., 2012).

1.2.1. *Diagnosing MUS*

A diagnosis of MUS can only be made by a medical doctor, who must engage in a careful investigation of symptoms to exclude organic causes (so-called 'diagnosis by exclusion'). This process is also referred to as 'negative diagnosis' (i.e., saying what something is not), as opposed to 'positive diagnosis' (i.e., saying what something is). Such diagnosis by exclusion is problematic because it seemingly reinforces mind-body dualism: if an organic explanation cannot be found then that places the aetiology of the symptom in the mind (Creed et al., 2012). This dichotomisation does not fit the spectrum of physical symptom experience. Indeed, it is very difficult to give some somatic symptoms a definitive positive diagnosis. Back pain, for example, can be particularly difficult to categorise, and symptoms such as this are known as 'borderline' (Mayou, 1993). Similarly, symptoms that are related to an organic disease but where the experience of them is deemed excessive, or symptoms that remain after organic disease has been successfully treated, pose particular diagnostic difficulties. Therefore, being certain a symptom is medically unexplained is extremely difficult; indeed, making such a classification has been shown to have low inter-rater reliability (Kroenke, 2007; Rief, Mewes, Martin, Glaesmer, & Brahler, 2011). For these reasons, the latest edition of the diagnostic and statistical manual for mental disorders (DSM-5, APA, 2013), no longer incorporates the concept of MUS into the diagnosis of disorders characterised by distressing physical symptoms (except in the case of conversion disorder; see section 1.2.2 for further discussion).

A current diagnosis of MUS does not preclude a medical cause from being identified in the future. Nor does it mean that those with MUS are at any less risk of developing medical problems. A prospective population-based study found that those who reported chronic widespread bodily pain (a symptom of fibromyalgia, a medically

unexplained illness) were more likely to develop cancer and were less likely to survive (McBeth, Silman, & McFarlane, 2003). However, follow-up studies have found that only a small minority of patients diagnosed with MUS are later found to have an organic cause for their symptoms (Crimlisk et al., 1998; Reid, Crayford, Patel, Wessely, & Hotopf, 2003; Stone et al., 2009).

It is often thought that patients pressure doctors to provide medical explanations for their symptoms. In fact, evidence suggests that it may be doctors, rather than patients, who are responsible for arranging further, potentially unnecessary, physical investigations (Ring, Dowrick, Humphris, Davies, & Salmon, 2005; Salmon, Humphris, Ring, Davies, & Dowrick, 2007). Many doctors engage in a lengthy and distressing diagnostic search, involving multiple referrals and exhaustive testing, before making a diagnosis of MUS (Peveler et al., 1997). Even when doctors judge symptoms to be medically unexplained, they regularly offer ineffective medical interventions, such as medication and even surgery, often resulting in further iatrogenic harm to patients (Stanley, Peters, & Salmon, 2002; Barsky et al., 2005, Fink, 1992). Indeed, the majority of treatment costs for this patient group are due to medical investigation and not psychiatric or psychotherapeutic treatment (Rost, Kashner, & Smith, 1994).

1.2.2. *Somatic symptom disorders and functional somatic syndromes*

In psychiatry, patients who frequently report physical symptoms that lack a medical explanation, or that are in excess of what would typically be expected, are thought to be manifesting a process known as somatisation. Somatisation is the tendency to experience and communicate somatic distress in response to psychosocial stress, and to seek medical help for it (Lipowski, 1988).

Until recently, in psychiatry MUS were categorised as somatoform disorders such as somatisation disorder, undifferentiated somatoform disorder, conversion disorder, pain disorder, hypochondriasis, body dysmorphic, disorder and somatoform disorder not otherwise specified (DSM-IV, APA, 1994). These categories of disorder are still in use by the international classification of diseases and related health problems (ICD-10, WHO, 2010). In all of these disorders, with the exceptions of hypochondriasis and body dysmorphic disorder, the primary preoccupation is with MUS, which cause clinically significant distress or impairment. The primary preoccupation in hypochondriasis is with fears of contracting, or fears that one has, a serious illness, which may or may not involve

the presence of MUS. In contrast, the primary preoccupation in body dysmorphia is with imagined defects in appearance, and does not typically involve the presence of MUS. In the latest edition of the DSM (-5; APA, 2013), the somatoform disorders category has been renamed and undergone significant revision. Somatoform disorders are now referred to as 'somatic symptom and related disorders'. The diagnostic categories of somatisation disorder, hypochondriasis, pain disorder, and undifferentiated somatoform disorder have been subsumed under one main diagnostic category: somatic symptom disorder. Conversion disorder is still categorised as a related but specific disorder, however, it has been given a new title: functional neurological symptom disorder. Individuals who would previously have been diagnosed with hypochondriasis, and who also report MUS, would now receive a diagnosis of somatic symptom disorder. Individuals with hypochondriasis without MUS would receive a diagnosis of illness anxiety disorder (unless their illness anxiety was better explained by a primary anxiety disorder, such as generalized anxiety disorder). Similarly, those formerly diagnosed with pain disorder are now subsumed under the somatic symptom disorder diagnosis. Those with body dysmorphia are now located in an entirely new category: obsessive-compulsive and related disorders.

In research, there has been a shift away from regarding MUS as a defining feature of somatic disorders and DSM-5 has followed suit (Mayou et al., 2005). Previously, under DSM-IV criteria, a 'symptom threshold' of at least eight MUS in different bodily symptoms had to be met before a diagnosis of somatization disorder was given. Under DSM-5, no specific number of symptoms is required for a somatic symptom disorder diagnosis, nor must symptoms be medically unexplained. This is consistent with evidence, outlined in Section 1.2.1, that the reliability of the MUS concept is limited and high symptom reporting, whether medically explained or unexplained, is independently predictive of impairment and health care use (Jackson et al., 2006; Barsky et al., 2005). In conversion disorder (now functional neurological symptom disorder), MUS remain a key feature, as patients often present signs which can be definitively shown to be inconsistent with organic pathophysiology (e.g. tremors that reduce when attention is distracted; Schwingenschuh et al., 2011).

Removing the symptom threshold marks a significant change for DSM-5, and reflects empirical evidence regarding prevalence rates. A systematic review of studies employing the restrictive DSM-IV criteria found that the prevalence of diagnosable somatisation disorder was so low in both population-based and primary care samples that researchers were unable to assess epidemiological features reliably (Creed & Barsky,

2004). As the DSM-IV criteria for somatisation disorder were so restrictive, researchers employed more relaxed definitions such as abridged somatisation (4 symptoms in women; 6 in men; Escobar et al., 1987) and multisomatoform disorder (3 symptoms; Kroenke et al., 1997). This resulted in widely varying prevalence estimates for polysymptomatic somatisation. In a primary care study, less than 1% of patients met criteria for somatisation disorder, 6% met abridged disorder criteria, and 24% met multisomatoform disorder criteria; 79% had a single symptom and met criteria for undifferentiated somatoform disorder (Lynch, McGrady, Nagel, & Zsembik, 1999). The various studies in this area show that bodily symptoms are continuously distributed in population and primary care samples (Katon et al., 1991); as such, any cut-off points are arbitrary unless research can consistently demonstrate that they reliably identify qualitatively different groups. The new somatic symptom disorder diagnosis in DSM-5 is one solution to this problem; however, subsuming these disorders under the same diagnosis suggests a similar aetiology for all MUS, regardless of the type of symptoms or comorbid psychological factors, which has yet to be demonstrated empirically.

Patients with MUS are rarely referred to psychiatry for treatment, since many do not have concurrent psychological symptoms and other psychosocial risk factors (e.g. stressful life events) are not evident. The vast majority of patients with MUS are seen in general medicine, where MUS may be classified under the 'functional somatic syndromes'. The term 'functional' is used to denote an alteration in function, rather than in structure, to account for compelling symptoms in the absence of underlying pathology (Trimble, 1982). The aetiology of functional somatic syndromes is often considered to be biological (e.g. a viral infection may lead to post viral fatigue then chronic fatigue, which may then be given the label chronic fatigue syndrome (CFS)). Table 1.1 below shows the range of diagnoses given by different medical specialities to patients with MUS.

Table 1.1 Common medically unexplained symptoms, and the diagnoses given to them in different medical specialities (adapted from Brown, 2007).

Speciality	Common unexplained symptoms	Common diagnostic labels
Psychiatry	Somatic symptoms and abnormal thoughts, feelings and behaviours related to symptoms	Somatic symptom disorder somatisation disorder; dissociative disorder
Neurology	Weakness, seizures, sensory disturbance and abnormal movements	Functional neurological symptom disorder; conversion disorder; dissociative disorder
Gastroenterology	Abdominal pain, diarrhoea, bloating, constipation, excessive flatulence	Irritable bowel syndrome; non-ulcer dyspepsia
Cardiology	Chest pain, palpitations, fainting	Atypical chest pain
Rheumatology	Joint pain, fatigue, headaches, sleep disturbance	Fibromyalgia
Infectious diseases	Fatigue, headaches, poor concentration, joint pain	Chronic fatigue syndrome (myalgic encephalomyelitis)
Dentistry	Facial pain, headaches, tinnitus	Atypical facial pain, temporomandibular joint disorder
Infectious dentistry diseases	Lump in throat, breathing problems	Globus syndrome
Allergy	Fatigue, burning eyes, breathlessness, poor concentration, weakness, dizziness	Multiple chemical sensitivity
Respiratory medicine	Breathlessness, rapid breathing	Hyperventilation syndrome
Gynaecology	Pelvic pain, pain during sex, dysmenorrhoea, painful urination, urinary retention	Chronic pelvic pain
Military Medicine	Fatigue, headaches, muscle pains, neurological symptoms, poor concentration	Gulf war syndrome

Giving clusters of MUS such 'medical' labels seems to confer legitimacy for both the symptoms and the sufferer and avoids the stigma of a psychiatric label. Indeed labelling of an illness can bring great relief to patients (Page & Wessley, 2003). In one study of CFS patients, 90% said that receiving a diagnosis was undoubtedly the most helpful experience they had had during their illness (Woodward, Broom, & Legge, 1995). However, the functional syndrome labels are not universally accepted. CFS, for example, is still widely known as Myalgic Encephalomyelitis (ME), with the two names seeming to infer quite different aetiologies. Both the label and the criteria used to arrive at the label have been a source of discord between patients, their support groups, and the medical profession. Some doctors do not feel comfortable diagnosing a condition that is poorly understood or that in many instances does not lead to any specific treatment (Wearden & Chew-Graham, 2006).

1.2.3. *Heterogeneity versus homogeneity of diagnosis*

Within general medicine the range of MUS experienced by patients is often not covered by a single diagnosis (Nimnuan et al., 2001). As a result, patients often have multiple comorbid diagnoses to encompass all of their symptoms. It has been argued, however, that the different diagnoses are largely a product of the diagnostic process (Wessley, Nimnuan, & Sharpe, 1999), which reflects treatment strategies, rather than the processes underlying disorder. Comorbidity between the functional syndromes has led some to suggest that the same pathophysiological processes may underlie them (Kirmayer & Robbins, 1991a). In support, Nimnuan et al., (2001) found that 30% of the variance in symptomology across functional syndromes could be accounted for by one factor, indicative of a common element. However, others have not found evidence to support uni-dimensionality in functional syndromes (Kirmayer et al., 1997). Similarly, it has also been hypothesised that a common process may underlie both the somatic symptom and conversion disorders (Brown, 2004; Edwards, Adams, Brown, Pareés, & Friston, 2012), whilst others have suggested a different process underlies conversion disorder (Kihlstrom, 1992).

There is also ambiguity about the extent to which the functional syndromes (IBS, CFS, etc.) overlap with somatic symptom and related disorders. Some argue that the two categories simply refer to the same patient group and that a unified diagnostic system is required (Mayou, Kirmayer, Simon, Kroenke, & Sharpe, 2005). In fact, many medical

doctors view functional somatic syndromes as the somatic expression of distress (i.e. somatisation; Robbins, Kirmayer, & Hemami, 1997). Studies have shown that some patients with functional syndromes have a history of somatisation which predates the onset of the functional syndrome (Barsky & Borus, 1999). In addition, functional somatic syndromes have been found to have high comorbidity with psychiatric disorders (Henningsen, Zimmerman, & Sattell, 2003). Together, these findings may indicate that some patients have a pre-existing tendency to experience and seek help for bodily distress (Barsky & Borus, 1999).

Others have disagreed with this view and see it as oversimplifying a very complex problem (Brown, 2007). Henningsen, Zipfel and Herzog (2007), have referred to patients who present a functional syndrome without unrelated symptoms (i.e. symptoms which are not related to the functional syndrome) as 'simple', and to those who present with functional syndromes and who also have many unrelated symptoms as 'complex'. Similarly Kirmayer et al., (1997) have suggested a distinction between so-called 'diversiform' and 'high frequency' somatisers. The former term refers to somatisers who experience multiple symptoms across functional systems, and who often have psychiatric comorbidity; the latter to somatisers who have symptoms limited to a single functional system, or anatomical location. Distinctions between 'simple and 'complex' presentations (and hence diversiform and high frequency) may well reflect distinct illnesses with different aetiologies; however, they may also reflect a spectrum of severity with different exacerbating factors. At present, it is unknown whether separate processes underlie such presentations, or whether the same processes underlie both.

Epidemiological studies suggest that many aetiological factors can contribute to the experience of MUS, such as acute and chronic organic pathology, psychiatric disorders and stressful life events (Barsky & Borus, 1999). Thus, a patient group with any single functional syndrome or somatic symptom disorder diagnosis can be very heterogeneous, in terms of both symptomology and aetiology. It is, however, unclear whether a single common process underlies the range of MUS experienced.

It has been suggested that the debates regarding homogeneity and heterogeneity of disorders and syndromes are simply a reflection of the western medical model which has difficulty accommodating physical and psychological symptoms, which are not reducible to pathology or abnormal behaviour (Deary, 2005). The different diagnostic labels used to describe the range of symptom experience may simply reflect the medical model, rather than any clear aetiological differences. The myriad ways in which MUS are classified,

however, are likely to remain until the underlying process or processes are clearly explicated.

1.2.4. *An alternative view*

An alternative conceptualisation of MUS comes from Kirmayer and Robbins (1991a) who categorise MUS into three distinct forms of somatisation: functional somatisation, hypochondriachal somatisation and presenting somatisation. *Functional somatisation* refers to the presence of multiple MUS that cannot be entirely attributed to the presence of a psychiatric condition, although there may be comorbidity. *Hypochondriachal somatisation* refers to normal sensations or minor symptoms that are misinterpreted as evidence of serious illness, usually by those with high levels of health anxiety. *Presenting somatisation* refers to the somatic presentation of a psychiatric disorder, such as anxiety or depression, and implies that the person denies a psychological explanation of their symptoms. Although there is overlap between these three categories, these authors found that a majority of patients only met criteria for one type of somatisation (see Figure 1.1 below). This was interpreted as suggesting that different pathological processes may underlie the symptoms produced in each type of somatisation.

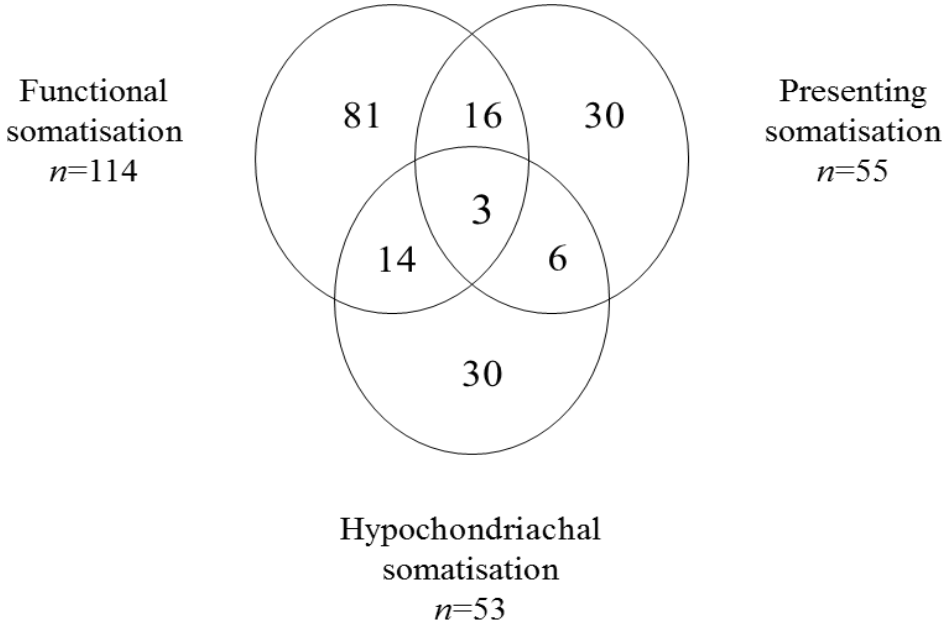

Figure 1.1 *A Venn diagram of the relationship between the three forms of somatisation (n= total no. of patients in sample with each form of somatisation; adapted from Kirmayer & Robbins, 1991).*

1.3. Operationalising MUS

The difficulties identified with the concept of MUS suggest that the broader tendency to report physical symptoms (medically unexplained or otherwise) may be of greater interest and utility to theorists and researchers in this area. Indeed, there has been increasing use of general symptom counts and severity monitoring to identify 'high symptom reporters' rather than patients with MUS per se, reflecting the idea that high symptom reporters are more likely to report symptoms that are medically unexplained (Kroenke & Spitzer, 1998; Henningsen et al., 2007; Ladwig et al., 2010; Korber, Frieser, Steinbrecher, & Hiller, 2011; Tschudi-Madsen et al., 2013). Ladwig et al., (2010) found that high symptom reporting (defined as scores in the upper quintile of the symptom distribution) identified a clinically meaningful population characterised by: fewer years of formal education, more chronic diseases, more psychological distress, impaired sleep, impaired self-rated health and greater health care utilisation. These associations remained significant even after adjusting for medical disease. This demonstrates that high symptom reporting is not simply a proxy measure for chronic ill health. High symptom reporting was also independently associated with health care use after controlling for socio-demographics, behavioural risk factors (e.g. smoking), physical illness and mental illness.

Similarly, a study conducted in primary care by Barsky et al., (2005) found that while high symptom reporters had more medical illnesses, more anxiety and more depression than low symptom reporters, none of these factors accounted for their increased health care utilisation. Thus, although medical illness and psychological disorders account for a large and important part of the variation in symptom reporting (Crombez, Beirens, Van Damme, Eccleston, & Fontaine, 2009), there is also a significant amount of variance unaccounted for that exerts an independent effect on outcomes (Ladwig et al., 2010). This unaccounted for variation could be attributed to a trait-like tendency to experience symptoms (and therefore MUS). These studies suggest that, by measuring symptom reporting rather than MUS, and controlling for relevant factors, clinically important phenomena can be identified and studied.

However, there remain differences between the theoretical underpinnings of the 'functional' and 'somatisation' constructs which have important consequences for operationalising MUS via symptom counts. By this view, for example, in order to be a 'somatiser' one must consistently report relatively high numbers of physical symptoms, with the implicit assumption being that high symptom reporters are more likely to

experience MUS. However, it is not necessary to report large numbers of unexplained symptoms to have a severe and debilitating functional (i.e. medically unexplained) syndrome. In a simple presentation of a functional syndrome there may only be a few symptoms reported (e.g. chronic lower back pain) as the functioning of only one physiological system or specific organ/location is affected. Nevertheless, the functional symptoms are medically unexplained and may cause significant impairment, distress and health care utilisation. In a large secondary care study, Nimnuan et al., (2001) found no overall association between the number of physical symptoms reported and MUS, only that those in the upper quartile of symptom reporting had a small non-significant increased risk of MUS. Therefore, whilst MUS and symptom reporting may both be regarded as trait-like phenomena with a spectrum of severity, the two spectra are not necessarily coincident.

Consequently, when using symptom counts any association found between symptom reporting and other variables may relate to *part* of the MUS spectrum but this does not necessarily capture processes relevant to simple presentations. Associations may be underestimates of the true relationship since those with simple MUS presentations may present as relatively low symptom reporters but may demonstrate similar processes to those reporting high numbers of symptoms (assuming that the same processes underlie the spectrum of MUS).

1.4. Factors associated with symptom reporting and MUS

Epidemiological and experimental research has consistently found a number of factors that are associated with both symptom reporting and MUS. The following section is not an exhaustive list of those factors, but highlights factors considered to be important in the development, maintenance and treatment of high symptom reporting and MUS.

1.4.1. *Demographic factors*

It has been found that women regularly report a greater number of physical symptoms than men, and that they report experiencing those symptoms more frequently and more intensely (Barsky et al., 2001). However, recent population-based studies have found more equivocal results. In a WHO primary care study, female sex was not a predictor of persistent high symptom reporting (Creed et al., 2012). A number of studies have found the experience of MUS to be greater in women (e.g. Carson, Ringbauer, Stone, McKenzie, & Warlow, 2000; Nimnuan et al., 2001). Thus, unsurprisingly the prevalence of

functional somatic syndromes and somatoform disorders has also been found to be higher among women. However, in the case of somatisation disorder, when the threshold for symptoms is lowered, this predominance decreases (Aggarwal, McBeth, Zakrzewska, Lunt, & Macfarlane, 2006). For hypochondriasis, there has been no significant sex difference reported (Creed & Barsky, 2004).

A number of hypotheses have been put forward to account for the often-observed sex differential in symptom reporting and MUS, such as biological differences, perceptual differences, socialisation, gender roles and biases in research and clinical practice (Barsky et al., 2001). However, the increased rates of abuse, trauma and psychological distress reported by women are likely a significant factor (Jackson, Chamberlain & Kroenke, 2003; Barsky et al., 2001).

A curvilinear relationship exists between age and symptom reporting. Symptom reporting steadily increases with age and peaks in both women and men at around age 55-59, after which there is a decrease in symptom reporting for older adults (Ladwig, Marten-Mittag, Formanek, & Dammann, 2000). Conversely, medical illness and health care utilisation maintain a steady linear relationship with age. Unsurprisingly, then, high symptom reporting and MUS are associated with younger adults (Carson et al., 2000; Nimnuan et al., 2001; Smith, Monson, & Ray, 1986).

1.4.2. *Personality traits*

The personality trait most consistently linked with MUS is negative affectivity (NA; Van Diest, et al., 2005; De Guchte, Fischler, & Heiser, 2004a, 2004b). Trait NA is the tendency to respond to one's environment with negative or distressing emotions, and to be introspective and self-critical (Watson & Clarke, 1984). Trait NA is also highly related to anxiety, depression and hypochondriasis (Pennebaker, 1982; Watson & Pennebaker, 1989). However, trait NA is independently associated with unexplained symptoms of comorbid psychiatric problems and psychological distress (Neeleman, Bijl, & Ormel, 2004; Rosmalen, Neeleman, Gans, & de Jonge, 2007).

Trait NA correlates with both retrospective and daily symptom reports (Aronson, Barrett, & Quigley, 2006), and has been found to predict symptom reporting even when controlling for medical disease and state NA (Cohen, Doyle, Skoner, Fireman, Gwaltney, & Newsom, 1995). However, trait NA is not associated with objective markers of health, long-term objective health status or health care utilisation (Watson & Pennebaker, 1989).

So, while high trait NA persons report more symptoms, they do not necessarily engage in the increased health care utilisation associated with high symptom reporting and hypochondriasis (Watson & Pennebaker, 1989).

It has been suggested that the relationship between trait NA and symptom reporting is due to a tendency to over-report (i.e. a bias for remembering symptom experience as particularly distressing) symptoms. Evidence suggests that high trait NA persons remember more physical symptoms (Watson & Pennebaker, 1989; Larsen, 1992). However, trait NA was found to be associated with current symptom reports and not retrospective illness episodes in older adults, suggesting that trait NA may not simply bias memory recall (Mora, Robitaille, Leventhal, Swigar, & Leventhal, 2002; Watson & Pennebaker, 1989; Costa & McCrae, 1987).

It has also been suggested that the relationship is due to an increased sensitivity for somatic sensations or an amplifying cognitive style (e.g. somatosensory amplification; see below). In support of this view, trait NA has been associated with hypervigilance, self-focused attention, and a bias towards internal sensations (Watson & Pennebaker, 1989; Feldman, Cohen, Doyle, Skoner, & Gwaltney, 1999; Stegen, Van Diest, van de Woestijne, & Vann De Bergh, 2001). Evidence suggests that anxiety may intensify unpleasant sensations such as pain; indeed, trait NA and anxiety are highly correlated with one another (Watson & Pennebaker, 1989). However, experimental evidence suggests that high trait NA is not associated with greater sensitivity for internal sensations (Aronson, Feldman, Barrett & Quigley, 2001; Steptoe & Vogele, 1992; Whitehead, Drescher & Blackwell, 1976, Aronson et al., 2006). In fact, evidence suggests that trait NA may be associated with *reduced* somatic sensitivity (Gardner, Morrell, & Ostrowski, 1990).

Rather than being more sensitive, high trait NA persons may have a tendency to negatively interpret sensations (Cioffi, 1990). In support of this, trait NA has been found to negatively influence sensation and symptom attributions (Stegen et al., 2001; Petrie, Moss-Morris, Grey, & Shaw, 2004). More recently, experimental evidence has shown that high trait NA and high symptom-reporting females make, when primed, more negative symptom attributions under conditions of low internal perceptual load. This finding has been interpreted as a tendency to rely on schema-driven interpretations of sensations, rather than bottom-up sensory information (Bogaerts et al., 2010). Whilst the specific processes that underlie the relationship between symptom reporting and trait NA, remain at present unclear, trait NA undoubtedly contributes to the experience of physical symptoms independently of other known covariates.

Another trait associated with MUS is alexithymia, which involves difficulty in recognising, articulating or conveying one's own emotions and their somatic components (Sifneos, 1973). It is thought that alexithymic patients find it difficult to recognise that physical sensations and symptoms are often the product of affect, and so sensations are identified as pathological (i.e. as symptoms rather than emotions). Alexithymia has been associated with the experience of MUS (De Gucht & Heiser, 2003; Mattila et al., 2008, De Gucht et al., 2004b), although this association has not been found in all studies (Kooiman, Bolk, Brand, Trijsburg, & Rooijmans, 2000). A lack of prospective studies means that alexithymia cannot, however, be considered a predisposing factor for MUS without further research (De Gucht & Heiser, 2003).

1.4.3. *Attribution and beliefs*

The attribution of symptoms is an important component of cognitive-behavioural models of MUS and hypochondriasis (e.g. Deary, Chalder, & Sharpe, 2007). High symptom reporters in primary care have been found to make more organic attributions for sensations (Robbins & Kirmayer, 1991). Deary et al. (2007) have also demonstrated that the tendency to make rigid attributions for physical symptoms is associated with symptom reporting. Cognitive behavioural models propose that these attributions are based on higher order maladaptive beliefs concerning, for example, the deleterious consequences of activity and positive effects of rest (Rief, Hiller, & Margraf, 1998; Deale, Chalder, & Wessley, 1998). Factors such as health anxiety also contribute to maladaptive beliefs regarding the meaning of symptoms and health care utilisation (Rief, Hiller & Margaref, 1998). Although the attribution process does not explain how sensations and symptoms arise in the absence of pathology, it is nonetheless thought to be an important factor in the maintenance of symptoms and abnormal illness behaviours.

1.4.4. *Anxiety and depression*

Both anxiety and depression commonly occur with one another and have high comorbidity with functional syndromes and somatic disorders (Löwe, Spitzer, Williams, Mussell, Schellberg, & Kroenke, 2008; Henningsen, Zimmerman, & Sattell, 2003; Henningsen & Löwe, 2006). Anxiety and depression are associated with changes to the autonomic nervous system such as increased heart rate and gastrointestinal activity (Carney, Kenneth, Friedland, & Vieth, 2005; Hoehn-Sacric & McLeod, 2000). These

changes can result in a wide range of somatic symptoms. Associations between anxiety, depression and functional syndromes and disorders are in part due to their overlapping diagnostic criteria. However, anxiety and depression have also been linked to the development and maintenance of MUS (which will be discussed in greater detail in Section 1.6). Some theories of MUS consider psychological factors such as anxiety, depression or psychological distress more generally to be the cause of MUS (Breuer & Freud, 1895/1901; Janet, 1889, 1907). Other theories suggest anxiety and depression may intensify the experience of MUS via perceptual and cognitive processes. It has been suggested, for example, that the additional sensory noise elicited by anxiety and depression may increase the perception of somatic symptoms (Rief & Barsky, 2005). The experience of somatic symptoms may also elicit anxiety and depression, which further intensifies their perception (Barsky & Wyshak, 1990). However, MUS often exist in the absence of anxiety and depression, therefore MUS cannot be considered simply as the somatic presentation of anxiety and depression (Nimnuan et al., 2001; Henningsen et al., 2003), and nor can they be due only to the perceptual amplification of bodily symptoms as a consequence of anxiety and depression (Kimayer & Robbins, 1991; Löwe et al., 2008).

1.4.5. *Hypochondriasis*

Another factor commonly associated with MUS is hypochondriasis (Creed & Barsky, 2004). Hypochondriasis is characterised by excessive concerns or anxiety about illness (health anxiety) and the belief that one has a serious undiagnosed physical disease (disease conviction), to the extent that it interferes with normal activities. Prevalence rates for hypochondriasis range from 3-13% in non-clinical and clinical populations (Barsky, Fama, Bailey, & Ahern, 1998). Although DSM-IV defined hypochondriasis is relatively rare in the general population, health anxiety more broadly is common and spans a spectrum of severity (Creed & Barsky, 2004; Creed, 2006). Health anxiety is considered both a trait and state variable, with the majority of health anxiety in primary care thought to be transient and related to concurrent anxiety and psychosocial stressors (Barsky, Wyshak, & Klerman, 1990). However, the persistent experience of high levels of health anxiety is considered to reflect an underlying personality trait which gives rise to somatic and psychological distress, and may be related to negative affectivity (Kirmayer & Robbins, 1990). Those with both high health anxiety and MUS are considered to have an amplifying somatic style, termed ‘somatosensory amplification’ (Barsky, Goodson, Lane,

& Cleary, 1988). Somatosensory amplification is the tendency to selectively focus on and amplify somatic sensations, to interpret them as distressing, and attribute them to pathology. This process was proposed to explain somatic symptoms related to hypochondriasis and will be discussed in greater detail in Section 1.6.4.

The close association between health anxiety, symptom reporting and MUS and lack of empirical evidence regarding the differences between hypochondriasis and somatisation disorder have led to the current revisions in the DSM-5 (Creed & Barsky, 2004). However, in research regarding the development and maintenance of MUS it may be important to differentiate between physical symptoms considered to be related to hypochondriachal versus functional somatisation (Kirmayer & Robbins, 1991).

1.5. Longitudinal and treatment studies

Prospective studies in primary care suggest that MUS remit spontaneously in approximately 50% of people over the course of a year (Creed & Barsky, 2004). However, this still leaves a large proportion of people for whom physical symptoms continue to cause distress and disability (Stone, Sharpe, Rothwell, & Warlow, 2003). There are two main categories of treatment available: medication and psychological therapies (e.g. cognitive behavioural therapy (CBT), and psychodynamic therapy (PDT)). Although studies suggest psychopharmacological and psychological therapies are beneficial in the treatment of MUS, effect sizes are modest and the treatment gains of psychological interventions tend to be short-lived (Price, 2000; Sollner & Schussler, 2001; Kroenke, 2007; Kroenke & Swindle, 2000; Allen et al., 2002). Remittance has typically been attributed to a reduction in anxiety and depression; however, this is not true of all cases (Creed & Barsky, 2004; Gureje & Simon, 1999). Indeed, in psychological treatment trials improvements have been achieved usually without a significant reduction in anxiety and depression (Kroenke & Swindle, 2000). The number of symptoms reported and levels of health anxiety may be better predictors of outcome than anxiety and depression (Jackson & Passamonti, 2005). In line with Kirmayer and Robbins' (1991) three forms of somatisation, the results of longitudinal and treatment studies suggest that anxiety, depression, number of physical symptoms and health anxiety should be regarded as separate but related dimensions. Future research should differentiate between them in order to identify relevant risk factors (Creed, 2006). Treatments are unlikely to improve without a clearer understanding of the processes relevant to these dimensions (Brown, 2007).

1.6. Psychological theories of the development and maintenance of physical symptoms

Whilst various factors have been associated with symptom reporting and MUS, the underlying mechanisms remain poorly understood. A lack of identifiable organic pathology entails that a sensory experience (i.e., symptoms) need to be accounted for at a different level of explanation. Psychological theories have emphasised the central role of cognitive processing, and in particular perceptual and attentional factors.

1.6.1. *Dissociation*

An early information processing model is Janet's dissociation theory (1889, 1907), which was developed to account for hysteria, a concept that was widely used in the 19th century to refer to a patients with a number of unexplained physical and psychological symptoms, including unexplained anaesthesia, amnesia, abulia, motor disturbances, changes in intellectual abilities and emotional reactivity. Janet suggested that the symptoms of hysteria arose when an individual's personality (i.e. their representational and processing systems) fragments in response to traumatic events. Janet proposed that 'hysterical' individuals have problems with their 'integrative capacity' (i.e. their ability to maintain an integrated personality), which renders them vulnerable to breakdown in the face of trauma. Consistent with this, there is substantial evidence to suggest that traumatised individuals experience more dissociative episodes and MUS than non-traumatised individuals (e.g. Brown, Schrag, & Trimble, 2005; Nijenhuis et al., 1998; Roelofs et al., 2002).

Janet proposed that integration is a primary function of attention and that "hysterical" individuals are subject to an involuntary narrowing of attention. This narrowing of attention produces unexplained symptoms via two processes. Firstly, attentional narrowing reduces the volume of sensory pathways that can be attended to at one time. Thus, some sensory pathways may become overly focussed upon, whilst other pathways are ignored. This may result in the loss of attentional control over ignored pathways. Consequently, information from these ignored pathways can no longer be processed in conscious awareness, although subconsciously information is being processed. Janet proposed that this process explained how medically unexplained anaesthesia and amnesia occurred. Other MUS were explained by another process, the activation of dissociated memories. In these cases, attentional narrowing creates bodies of

information that are separate from consciousness and which are unable to be integrated with new memories or information. When activated, these bodies of information may then be misinterpreted as perceptions rather than recollections (Brown, 2004).

Following this hypothesis it would seem logical that symptoms present at the time of trauma, although not experienced due to the process of dissociation, would directly map onto the type of MUS currently experienced. For example, we would expect to find patients with medically unexplained pain to have been subject to traumatic experiences that involved pain, although they may not have experienced the pain of the traumatic experience at the time. In many cases of MUS a history of traumatic experiences is simply not evident, however (Ron, 1994; Wessley, 2001).

1.6.2. *Conversion*

Another explanatory model of MUS comes from Breuer and Freud (1895/1901) who introduced the concept of conversion. They hypothesised that the brain protects itself from extreme negative affect by unconsciously suppressing recall of the experiences giving rise to that affect. This process results in dissociated knowledge being held outside conscious awareness by an amnesic barrier. The emotional energy associated with these dissociated experiences is not able to be "discharged", which causes an energy imbalance. In order to manage this imbalance, the brain converts the energy from these experiences into physical symptoms that were either present at the time of the trauma or are a symbolic representation of it. In this model, therefore, MUS are a product of 'conversion', a defence mechanism which aims to reduce anxiety as its 'primary gain'. There may also be 'secondary gains' associated with being ill, such as attention and sympathy from others.

Conversion theory remains a popular explanation for MUS. Studies have shown that adverse experiences in childhood are associated with frequent medical consultations in population and primary care samples (Katon, Sullivan, & Walker, 2001). In secondary care, reports of childhood adversity are greater for those with MUS than those with explained symptoms (Fiddler, Jackson, Kapur, Wells, & Creed, 2004). However, conversion theory is unable to accommodate those who experience MUS in the absence of negative affect or traumatic events.

Breuer and Freud's emphasis on primary and secondary gains has also been influential in behavioural approaches, which highlight the importance of reinforcement such as attention or time off work in the maintenance of MUS (Brown, 2004). However,

research also suggests that significant secondary gains are not made in many cases of MUS and are no greater than in general medical illness (Brown, 2004). In addition, the conversion model has been described as over-specified relative to the evidence and has been criticised for the circularity of its hypotheses (Brown, 2004). The lack of traumatic experiences or negative affect in many cases of MUS is a problem for early dissociation and conversion theories. However, when patients deny psychological problems or traumatic experiences proponents of conversion theory suggest that they are repressing the experiences, conveniently 'confirming' the theory. Similarly, the increased psychiatric co-morbidity found in functional somatic syndromes and disorders is particularly problematic for conversion theory. If the conversion process was working effectively, significant psychopathology would not be expected since psychological distress should be effectively converted into physical distress (Brown, 2004).

Both conversion theory and dissociation theory have dominated the conceptual and clinical landscape; however, their inability to account for the experience of MUS in the absence of a history of trauma or negative affect has seen the rise of neo-dissociation models, and information processing theories more generally in the last 30-40 years.

1.6.3. *Neo-dissociation*

In Janet's theory, dissociation is considered an abnormal process experienced only by "hysterical", weak-minded individuals. Most models now view dissociation as a normal psychological process, employed by individuals to varying degrees. Unexplained symptoms are only thought to occur when this adaptive dissociative process is over-used (Hilgard, 1977). Ludwig (1972) suggested that MUS are the result of an attentional dysfunction caused by the inhibition of afferent stimulation. This inhibition results in a dissociation between high-level attention and sensory sources of information, which prevents the integration of sensory information with conscious awareness. In support of this, experimental evidence suggests that (at least for conversion disorder) relatively intact early processing is combined with high-level attentional deficits in vigilance, habituation and cognitive flexibility (Brown, 2004).

Hilgard's (1977) neo-dissociation theory asserts that dissociation is fundamental to cognitive processing in general, and not to a pathological or defensive response. Hilgard proposed that behaviour is controlled by cognitive systems which are horizontally dissociated from one another. Although these systems are autonomous, they are organised

hierarchically, under the control of an executive ego. This cognitive architecture allows well-learned behaviours, for example, driving and writing to be performed automatically in a way that feels effortless and outside conscious awareness. According to Hilgard, activities such as driving are everyday examples of dissociative phenomena. Neo-dissociation theory has also provided an influential account of hypnotic phenomena. Hypnosis is considered to occur via inhibition of the executive ego. Hypnotic suggestions are thought to maintain a vertical dissociation between two sides of the executive, splitting it into two processing pathways. One pathway is hidden beneath an amnesic barrier, rendering it inaccessible to conscious awareness; suggestions to this unconscious part of the executive are able to communicate with the lower sub-systems, which are responsible for initiating behaviours such as movement. Whilst the conscious part of the executive has no awareness of the unconscious part, or the unconscious part's communications with lower subsystems, it consequently experiences suggested behaviours as involuntary. More recently, it has been suggested that this dissociation is horizontal and that hypnosis completely inhibits the executive and that suggestions *directly* activate the lower subsystems.

Khilstrom (1992) has applied neo-dissociation theory to MUS associated with conversion disorders. He suggests that symptoms involving sensory loss, for example, are caused by dissociation between the executive ego and the sensory systems which encode and store information. This would involve intact sensory processing, but high-level pre-conscious attentional deficits. Experimental evidence supports this kind of deficit in relation to conversion seizures (Kuyk, Spinhoven, & van Dyck, 1999). In this way, the neodissociation model and its predecessors are able to account for perceptual experiences (such as compellingly real symptoms) in the absence of peripheral stimulation. Dissociation and neo-dissociation models have, however, been criticised for their lack of detail in explaining the mechanism by which high-level attentional deficits operate (Brown, 2004). Also, while the explanations of MUS associated with conversion disorders (e.g. unexplained sensory loss) are compelling, it is more difficult to apply the dissociative framework to more common forms of MUS, such as those characteristic of functional somatic syndromes and disorders. This lack of clarity regarding specific cognitive mechanisms suggests that greater emphasis should be placed on the attentional and perceptual processes by which MUS arise.

1.6.4. *Biopsychosocial models*

Later models have attempted to explain the perception of physical symptoms in general and have focused on different aspects of selective attention and perception (Pennebaker, 1982; Barsky & Wyshack, 1990; Rief & Barsky, 2005; Cioffi, 1991). Central to Pennebaker's (1982) model of symptom perception is the hypothesis that people are only able to process a small amount of the total information that is available to them at any one time. Therefore, physical symptom reports vary as a consequence of the external load of perceptual information to which we are subjected. As the external load of information increases, our attention to internal stimuli will decrease, and *vice versa*. Internal and external cues compete for our limited attentional resources and this process is known as the 'competition of cues'. Focusing attention internally is likely to increase how many symptoms we notice and report. In support of this hypothesis several studies have demonstrated that in boring environments (i.e. those considered to have low external load) more symptoms are reported (Pennebaker, 1982, Pennebaker & Lightner, 1980; Pennebaker & Brittingham, 1982). However, an internal focus of attention alone is not enough to cause MUS. Pennebaker proposed that another process known as the 'selective search' then operates to selectively monitor for certain types of sensations based on cognitive factors (e.g. hypervigilance for symptom-related information). Sensations are then further elaborated via interpretive processes. Only when attention to the body is coupled with the selective search for illness-relevant information will the perception of somatosensory information be altered. Pennebaker's model clearly outlines the roles of body-focused attention in bringing more sensations into awareness; it does not, however, clearly explain how those sensations become symptoms. While internally focusing attention may make already-present symptoms more salient, which then may be interpreted as consistent with illness schema via the selective search, how MUS are generated *de novo* is less clear.

Following the work of Pennebaker, Barsky and colleagues have presented a model which focuses more specifically on the selective search and interpretation of sensations. Somatosensory amplification (See Figure 1.2; Barsky et al., 1988; Barsky & Wyshak, 1990) has become a popular explanation for MUS in general, although it was originally proposed to explain symptoms in relation to hypochondriasis, and to account for the consistent relationship between symptom reporting and NA. Somatosensory amplification is thought to reflect an amplifying perceptual style which entails hypervigilance for

somatic sensations, and a tendency to respond to sensations with negative affect and cognitions. Because sensations and symptoms are experienced as particularly disturbing and intense they are interpreted as being signs of serious disease. Health anxiety causes additional hypervigilance for somatic sensations, which further amplifies symptoms through two main mechanisms. Firstly, signals that confirm the pre-existing hypothesis (i.e., that sensations and symptoms are a sign of serious disease) are selectively attended-to and disconfirmatory signals are disregarded (Pennebaker, 1982). Secondly, increases in anxiety result in further symptoms that are also interpreted as inferring serious disease, resulting in greater alarm and creating a vicious circle. Problematic behaviours such as illness-preoccupation and reassurance-seeking are seen as secondary to, and a natural consequence of, the disordered perceptual experience that results from somatosensory amplification. The model of Barsky et al., clearly explains how selective attention, affect and beliefs can alter perceptual experience and has influenced subsequent models (e.g., the CBT model, Deary et al., 2007).

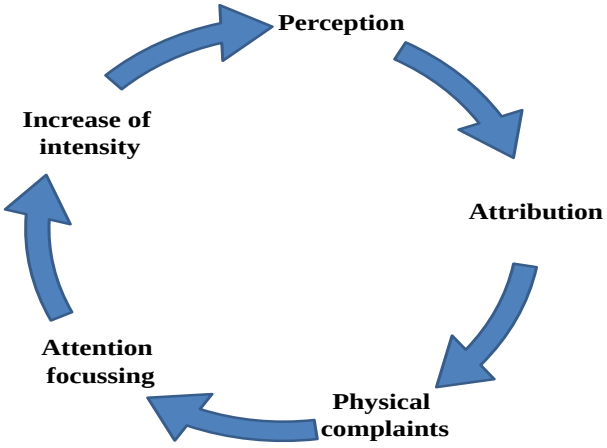

Figure 1.2 *A diagram of the somatosensory amplification model (Barsky & Wyshak, 1990; adapted from Rief & Broadbent, 2007).*

The cognitive-behavioural model of hypochondriasis (i.e., clinically significant health anxiety; Warwick & Salkovkis, 1990) also hypothesises a central role for cognitive processes such as body-focused attention, and the misattribution of physical sensations. However, this model identifies dysfunctional beliefs about health and illness (i.e. all symptoms must have a physical explanation) as being the primary causative factor in the development and maintenance of health anxiety. Dysfunctional beliefs in themselves may not be bothersome until they are combined with further experiences, such as the experience

of frequent stomach pains, which are then thought to activate beliefs and produce negative automatic thoughts or images (e.g., "I have stomach cancer"). These negative automatic thoughts are then thought to elicit a range of cognitive, affective, physiological and behavioural responses, which combine to form a vicious circle that maintains dysfunctional beliefs (see Figure 1.3 below). In line with the somatosensory amplification model, inert sensations and symptoms that are already present as a consequence of physiological arousal are then subject to anxious misinterpretation, which confirms existing dysfunctional beliefs.

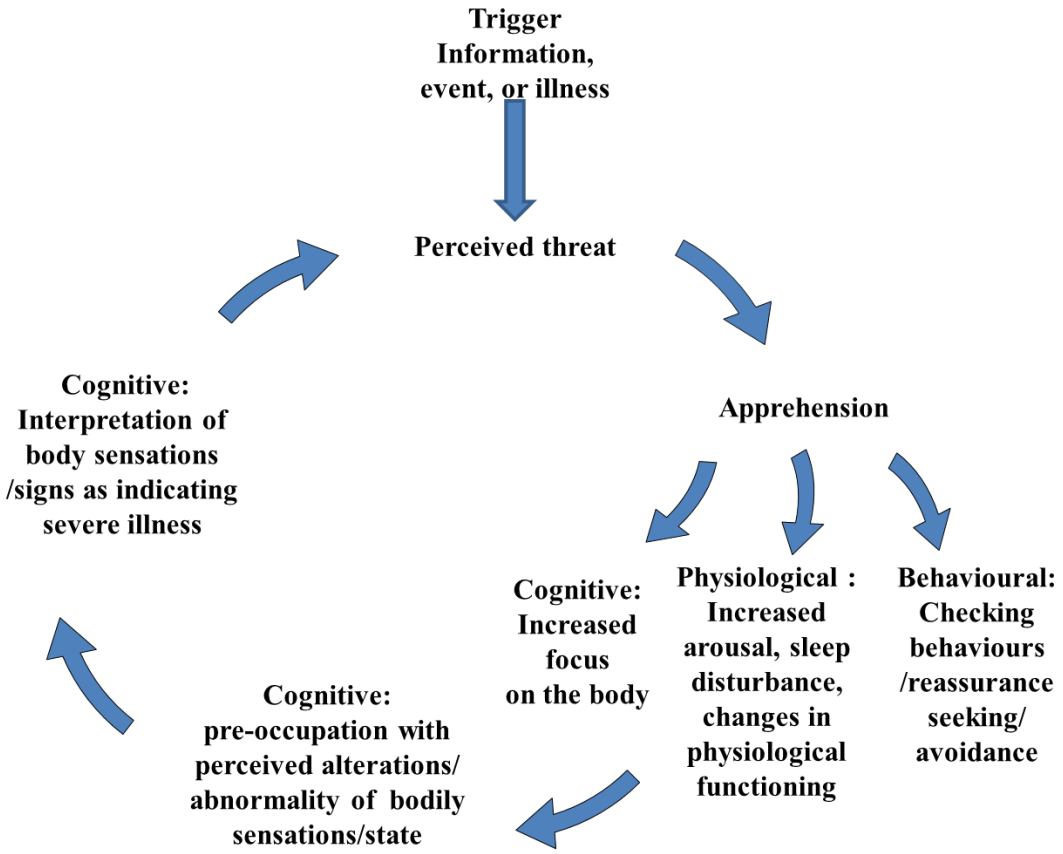

Figure 1.3 Maintenance model of severe health anxiety adapted from Warwick & Salkovkis (1990).

Both the somatosensory amplification model and the cognitive-behavioural model are less able to account for symptoms that do not seem to arise from the anxious misinterpretation of peripheral sensations (e.g. unexplained sensory loss). Indeed, evidence suggests that different processes may underlie symptoms associated with hypochondriachal somatisation and functional somatisation, suggesting that somatosensory amplification may explain the experience of some symptoms but not all (Kimayer & Robbins, 1991).

Treatment studies have shown that physical symptoms can be improved without reductions in anxiety and this poses problems for both models (Kroenke & Swindle, 2000).

More recently, Rief and Barsky (2005) have proposed a model of symptom perception which outlines three key stages in a hypothesised preconscious somatic filtering process and how changes may occur at each of these stages to give rise to MUS (see Figure 1.4). Rief and Barsky like others (e.g. Pennebaker, 1982) hypothesise that we are subject to a constant array of somatosensory signals or sensory noise from our bodies. They hypothesise that the majority of this noise never reaches consciousness because it is filtered out via a preconscious filtering system. However, the filtering system can be altered in three main ways that would allow more sensory noise to reach conscious awareness as somatic signals. Firstly, the strength of signals may be altered (e.g., due to over-arousal related to illness or anxiety). Secondly, changes may be made to the filtering process itself. Rief and Barsky identify a number of factors (e.g. body-focused attention) that may alter the filtering process, in effect decreasing its filtering capacity, so that more signals reach consciousness. Thirdly, certain factors may increase the conscious perception of signals, such as expectations.

Although the model of Rief and Barsky only focuses on one aspect of symptom perception, the perceptual selection process, it is one of the few to precisely elucidate how factors such as attention, mood and arousal may interact with a preconscious selection process to change awareness. However, it is not clear how perceiving more signals necessarily leads to the perception of symptoms. Rief and Barsky's model does not detail the interpretive processes that change sensations into symptoms or interpret sensations as consistent with illness schema. It has been suggested by Rief and Barsky that sensitisation may play an important role. Sensitisation is considered to decrease the filter and alter the unpleasantness or pain threshold such that lower levels of stimulation are needed to elicit symptom responses. This would suggest that the perception of pain or unpleasantness happens at a very early stage of perception. Thus, we might expect high symptom reporters to not only detect somatosensory signals at lower levels but that their symptom tolerance may also be lower. However, not all sensations that are used to interpret illness states are unpleasant or painful; Rief and Barsky propose that somatosensory amplification explains the interpretation of inert sensations as symptoms indicative of illness.

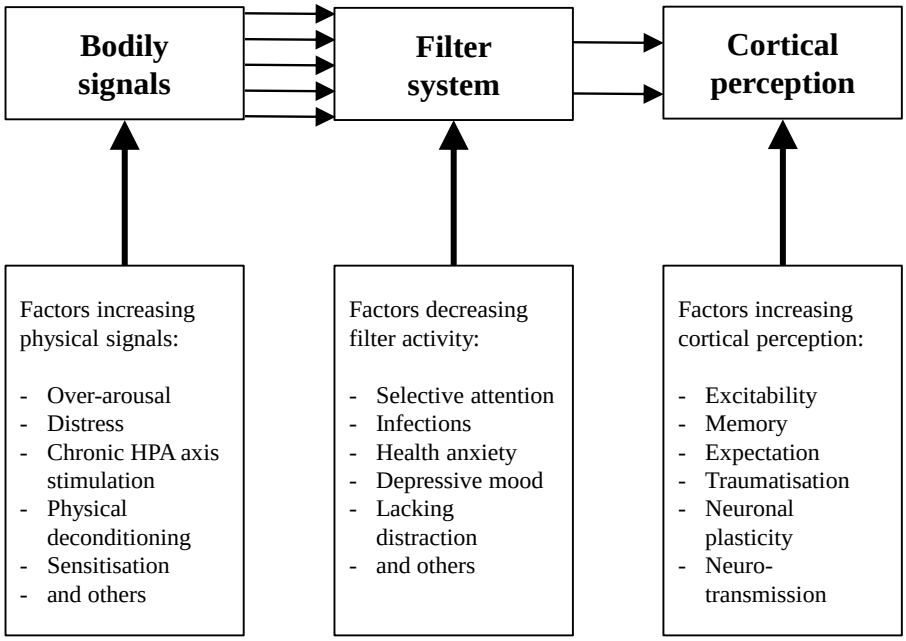

Figure 1.4 A diagram of the signal filtering model (Rief & Barsky, 2005, adapted from Rief & Broadbent, 2007)

Cioffi (1991) has further elaborated the concept of body-focused attention which is central to most theories of MUS (Pennebaker, 1982; Barsky & Wyshak, 1990; Rief & Barsky, 2005). Cioffi argues for a distinction to be made between focusing on physical sensations, which is what is generally implied by body-focused attention, and attending to threatening interpretations of somatic sensations. Cioffi questions the assumption that increased body-focused attention increases perception and that simply increasing perception increases distress. Cioffi suggests that the role of body-focused attention is interactive or 'plastic' rather than deterministic, and that attention interacts with affect to determine the meaning of somatic sensations (i.e. whether they are experienced as unpleasant or not) and hypotheses regarding their aetiology (Cioffi 1991; Cioffi, 1991a). In this model, body-focused attention may be thought of as contributing to awareness (i.e. how aware we are of somatic signals) and may be considered both pathological or salutogenic depending on its interaction with affect. Cioffi's model emphasises how perception may be affected at a later stage of processing than is suggested by perceptual models such as that of Rief and Barsky who emphasise early preconscious processing deficits. In Cioffi's model *a priori* beliefs are able to bias attention towards confirmatory information. Cioffi suggests that NA and symptom reporting may be associated via a tendency to attend to negative interpretations of sensations and symptoms rather than attending to the concrete features of sensations, perhaps due to avoidance of uncertainty.

The models outlined above all suggest a key role for body-focused attention and the misinterpretation of somatosensory signals. The processes by which symptoms develop are much more clearly stated than in the dissociative and conversion models discussed previously. Whether or not it is considered a pathogenic process in its own right or simply a process that works in conjunction with other processes to create pathology, body-focused attention is central to all of these models. The models propose that body-focused attention allows somatosensory signals to enter conscious awareness that would not normally be detected. These signals are then subject to interpretive processes. Therefore, the models also propose changes to the conscious awareness of those with unexplained symptoms.

1.6.5. *Current view*

More recently Deary et al. (2007) have combined current models, theories and experimental evidence in the cognitive behavioural model of symptom maintenance (Figure 1.5) and current CBT for MUS is based upon variations on this model. These models are useful for explaining symptoms that arise from peripheral physical changes, which may be subjected to processes such as hypervigilance and/or anxious misinterpretation. They are also useful for describing how behavioural factors, such as entry into the sick role, and psychological factors, such as negative affect, may maintain these processes. However, models such as this tend to be predominantly descriptive, say little about the underlying mechanisms involved, and therefore do not allow specific predictions to be derived from them (Rief & Broadbent, 2007).

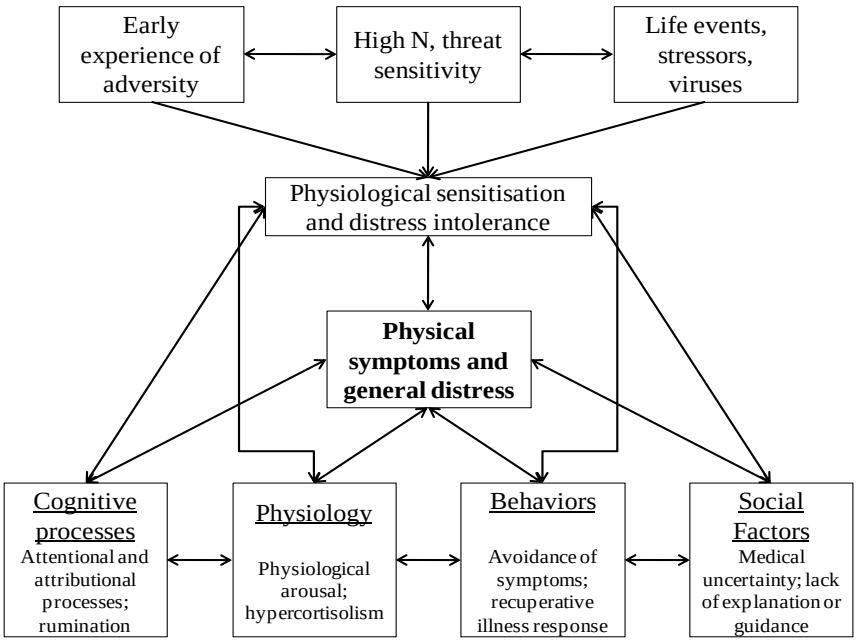

Figure 1.5 The cognitive behavioural model of symptom maintenance (Deary et al., 2007).

1.6.6. *Theoretical difficulties*

One particular problem with cognitive behavioural models, and biopsychosocial models more generally, is that they identify all unexplained symptoms as arising from normal physiological processes in the periphery that are exaggerated by perceptual, cognitive and social factors. Although this may account for many symptoms, it does not adequately explain MUS, which do not appear to follow this process, such as functional neurological symptoms like non-epileptic seizures. Whilst the biopsychosocial models discussed above do not hold that MUS are exclusively the product of trauma or psychological distress they nevertheless maintain a primary pathogenic role for psychological variables such as anxiety, health anxiety and NA. Indeed the models of Barsky and Wyshak, Cioffi and Deary et al. would find it difficult to explain how MUS could be created in their absence. Whilst it is important for any model to be able to explain how both trait and state psychopathology may affect the development of MUS, they must also be able to adequately account for MUS in their absence.

1.6.7. *An integrative model*

Brown's (2004) model was developed to address the shortcomings of previous perceptual models and draws upon the concepts of dissociation and conversion. The model

is based on empirical evidence regarding both attention and perception. Although originally developed as a model of somatoform disorder (e.g. functional somatisation), Brown's model can be applied to MUS and, indeed, symptom reporting more generally.

1.6.7.1. Somatic awareness

The Brown model differs from previous accounts by suggesting that MUS can be thought of as disturbances in awareness or cognitive control and the model attempts to explain these with reference to a model of normal awareness and control.

From 'within', our experience (including that of our bodies, that is, our *somatic awareness*) appears to be an accurate and objective account of the world. There are, however, many examples of somatic distortion that contradict this common-sense belief. For example, in phantom limb syndrome, people continue to experience sensations and pain in the location of an amputated limb (Ramachandran & Hirstein, 1998). Similarly, in the rubber hand illusion, people experience perceptually compelling sensations of touch on a fake rubber hand when it is stroked simultaneously with their own (hidden) hand (Botvinick & Cohen, 1998). Whilst these two examples provide compelling evidence regarding somatic distortion, they are not common everyday experiences. However, a recent study suggests that the experience of "phantom vibrations", the intermittent perception that a communication device is vibrating when it is not, is a much more commonly experienced form of somatic distortion (Rothberg, Arora, Hermann, Kleppel, St. Marie, & Visintainer, 2010). The experience of phantom vibrations demonstrates how our somatic awareness can be generated by top-down factors such as attention, memory and expectation; the Brown model identifies MUS as similar phenomena (Brown, 2004).

1.6.7.2. The creation of experience and rogue representations

Brown's model distinguishes between two different attentional systems within the broader cognitive system, the primary attention system (PAS) and the secondary attention system (SAS). The PAS is involved in the selection of routine cognitive processes that are perceived as intuitive and effortless as they are outside direct conscious control. The SAS is involved in the selection of cognitive processes that are under conscious control and are perceived as deliberate and effortful. Under this model, when sensory input is received a number of competing hypotheses pertaining to that input are generated. These hypotheses are determined by information stored in associative memory pertaining to similar input

encountered in the past. The PAS is influenced by a number of factors: the content of the sensory information, the activation level and selection threshold of competing representations in memory, and top down input from high-level attention. The most dominant hypothesis will be selected by the PAS and used to organize relevant perceptual and memorial information into so-called primary representations. Primary representations provide a coherent interpretation of the internal and external world for the execution of action. They also correspond to the contents of awareness, which are determined by both sensory input and information in memory. According to this model, unexplained symptoms can develop when symptom information in memory (so-called "rogue representations") become chronically activated, causing the PAS to use this information as a basis for interpreting current input. This results in a misinterpretation of the world, which is experienced by the individual as perceptually correct because the PAS is not under conscious control. In this sense, the model emphasises that MUS are not under volitional control by the individual.

Rogue representations can develop from exposure to illness in self and others (Hotopf, Mayou, Wadsworth, & Wessely, 1999), from verbal suggestion and social exposure to illness information (Brown, 2004). The type of symptom experienced depends on the nature of the rogue representation. Symptoms such as pain and nausea develop when an inappropriate perceptual hypothesis (i.e. one that conflicts with sensory information) is selected by the PAS during the development of primary representations. Unexplained symptoms like memory loss and blindness, where cognition and perception are not being properly controlled, develop when inappropriate processing routines are triggered by the PAS.

Brown's model echoes Janet's dissociation theory; in both theories MUS are the result of distortions in conscious awareness caused by dissociated information in the cognitive system. The model also assumes that the different levels of cognitive processing within the cognitive system are horizontally dissociated. However, Brown's model does not hold that MUS are necessarily the product of pathologic processing or defence mechanisms. Unexplained symptoms are considered a normal psychological phenomenon, developing from subtle disruptions in processing that control routine behaviours and perception. Conceptually this fits with evidence about the ubiquity and spectrum of severity of MUS.

1.6.7.3. Symptom-focused attention

Brown hypothesises that what makes the experience of unexplained symptoms chronic is symptom-focused attention (see Figure 2). Voluntarily directing attention onto symptoms (at the level of the SAS) increases the dominance of the rogue representation and consequently increases the likelihood of it being selected by the PAS. So any behaviour that increases symptom-focused attention, like body-focused attention, illness worry and rumination, will maintain the dominance of the rogue representation. Body-focused attention and symptom-focused behaviours are also identified as important in the CBT model. However in the CBT model these behaviours exacerbate hypervigilance for benign sensations and the anxious misinterpretation of those symptoms.

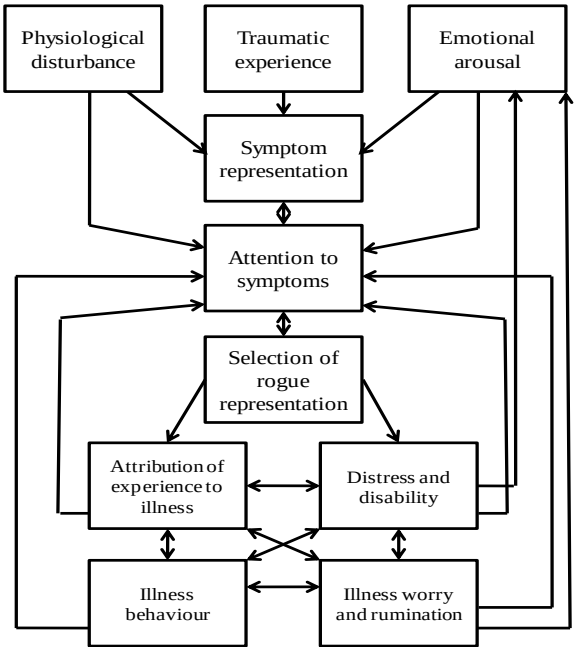

Figure 1.6 Factors involved in the development of symptom chronicity (feedback loops to rogue representations not shown, Brown, 2004).

1.6.7.4. Other factors influencing the development of MUS

Brown's model is able to account for MUS in the absence of psychopathology and trauma. However, it also acknowledges that factors such as psychopathology and trauma may influence attention and somatic awareness, although the contribution such factors make will vary greatly on an individual basis.

A history of childhood adversity and traumatic experiences is common in those with MUS. Studies have shown that adverse experiences in childhood are associated with frequent medical consultations in population and primary care samples (Nimnuan et al., 2001). In secondary care, reports of childhood adversity are greater for those with MUS than those with explained symptoms, particularly childhood sexual abuse and parental neglect, which had the strongest association with frequency of consultations (Fiddler et al., 2004). Brown suggests that this association may also be due to the use of symptom-focused attention as a psychological defence. Traumatic experiences result in varying degrees of negative affect, which the individual usually responds to through self-regulatory processes and goal oriented behaviours (Wells, 2000). However, depending on the type of trauma and the resources available to the individual, effective self-regulation and goal-orientated behaviours may not be possible. For instance, childhood experience of abuse may prevent the individual from learning effective self-regulation skills, whereas goal-oriented behaviours (e.g. physically defending oneself) may result in further abuse. In circumstances where self-regulation and goal-oriented behaviours are not possible, the cognitive system may rely upon internal processing to manage negative affect. In response to this deluge of affect, the SAS may divert attention to the body as a coping strategy which further increases the development and maintenance of MUS. The symptoms may therefore also represent a way of expressing negative affect without conscious awareness of its psychosocial source. Negative emotional states may also serve to increase symptom or body-focused attention, by directly influencing the encoding and storage of rogue representations. For example, extreme anxiety may lead to the selection of rogue representations via attentional narrowing (Brown, 2004).

Health anxiety is also associated with a state of body-focused attention and hypervigilance for symptom related information (Barsky & Wyshak, 1990). The misinterpretation of symptoms and illness behaviours may also increase negative affect. These factors are all hypothesised to contribute to the development of MUS by further fuelling attention to rogue representations.

Thus, Brown's model draws on dissociation, conversion and CBT theories to provide a more detailed cognitive-attentional model of unexplained symptoms. Central to this model is the idea that many unexplained symptoms are “top-down” generated distortions in somatic awareness, resulting from excessive symptom-focused attention. In this way, the model is able to explain how a wide range of MUS may be created *de novo*,

in the absence of peripheral physical changes and psychological distress, which is an important improvement on existing models.

Brown's model predicts that a symptom-focused attentional bias exists for those with MUS. This may be demonstrated by both facilitation for and delayed disengagement from symptom-relevant information. In contrast with the earlier biopsychosocial models, Brown's model suggests that it is not attention to bottom-up sensory experience which drives MUS (i.e. body-focused attention), but attention to top-down representations of symptoms (symptom-focused attention). However, the model is not clear about how the two different types of attention may interact or indeed how they may be distinguished empirically. Although there are conceptual differences between body-focused attention and symptom-focused attention, attending to representations of symptoms may automatically prime attention to the body, which may also confer a preference for the body. Thus it may be difficult to distinguish experimentally between body-focused and symptom-focused attention.

1.6.8. *A neurobiological account*

More recently, Edwards et al., (2012) have proposed a neurobiological model of hysterical (i.e. functional neurological) symptoms. In line with Brown, the authors propose that unexplained subjective symptoms such as fatigue and observable unexplained motor symptoms, such as functional tremor, are created by similar attentional and belief-driven processes. Their model of MUS is based on a hierarchical Bayesian formulation of brain function, in which the brain generates sensory predictions based on probabilistic beliefs about the causes of sensory information combined with current sensory experience. The terms belief and prediction in this model are used interchangeably to refer to probabilistic inferences regarding incoming sense data, which may or may not be consciously held. Fundamental to these predictions is the minimisation of surprise, in this case unexpected or unpredicted sensations (free energy principle; Friston et al., 2006; 2010). According to the free energy principle, and the rules of biological homeostasis in general, if surprise was not minimised this would eventually lead to sensory disorder. Surprise can be minimised by creating models of the causes of sensations, and using these models to make predictions about the causes of sensations. Surprise can then be minimised further by reducing discrepancies between predictions and sensory information (i.e. prediction error). This can be done in two ways: either by changing sensory information through action or by

changing predictions. Prior beliefs or predictions (top-down) regarding the content of sensation are conveyed down hierarchical levels via backwards connections, and sensory information (bottom-up) is conveyed via forward connections that pass any prediction errors up the hierarchy until they are adequately explained by changes in predictions. Expectations at any level of the hierarchy constitute prior beliefs for the level below. By minimising prediction errors the brain maximises evidence for its generative model of the world. Therefore, if very precise current sensory information is combined with imprecise predictions, perception will more closely represent the sensory information. If *vice versa*, then perception will more closely represent the prediction. So by changing the content and precision of prior beliefs and the precision of sensory information we are able to change perception. Thus very precise beliefs about the experience of physical symptoms, combined with less precise sensory information, may lead to the experience of MUS.

There are a number of studies that demonstrate the ability of prior beliefs or predictions to change perception (e.g. Pennebaker & Skelton, 1981; Pennebaker, 1982). Lorenz et al., (2005) gave participants painful laser stimuli preceded by cues predicting the intensity of subsequent laser stimuli. The cues were not always correct, however, with low intensity stimuli sometimes following high intensity cues and *vice versa*. The pain ratings of the participants were affected by the cue. Pain intensity perception was biased towards the cue, as was the amplitude of the magnetoencephalogram signal in the contralateral secondary somatosensory cortex. Altering expectations about visual stimuli has also been shown to change perceptual threshold and electrophysiological responses (Melloni et al., 2011).

These studies demonstrate the interaction between attention and expectation upon the processing of sensory information. Common to all MUS, then, are abnormal prior beliefs regarding the nature of sensory input, or movements that are given excessive precision by attention. This echoes the earlier work of Brown, where rogue symptom representations (i.e. predictions) are activated (i.e. afforded excessive precision) via attention. Affording beliefs too much precision has two main consequences. Firstly, the belief overwhelms less precise bottom-up information, creating further false perceptual inferences. Secondly, higher levels in the hierarchical structure now have to explain false inferences lower down the hierarchy, since the higher levels did not predict the exact sensory content of these false perceptual inferences (they only predicted higher level beliefs). Thus false perceptual inferences are experienced as involuntary symptoms.

The model of Edwards et al. like its predecessors, proposes a central role for attention, and more specifically attention to high-level beliefs, regarding the nature of sensory input or movement. However, Edwards et al. also emphasise the importance of intermediate prior beliefs or expectations and their interaction with attention to determine the contents of awareness. Like the Brown model, Edwards et al. see MUS as top-down generated intrusions in somatic awareness brought about by abnormal beliefs which are afforded undue precision *via* the repetitive allocation of attention. However, in Brown's model high-level attention to the 'rogue symptom representation', lowers its activation threshold, such that incoming sensory data automatically activates the rogue representation. The activated representation is then experienced in somatic awareness as a symptom. In contrast, in the model of Edwards et al. it is high-level attention to abnormal beliefs about the nature of sensory experiences which cause false perceptual inferences to be made, which are then perceived as symptoms. Thus the two theories propose that attention operates at slightly different levels to create MUS. Importantly, the model of Edwards et al., like Brown's, is able to account for MUS in the absence of significant psychological or biological precipitating factors, such as, trauma, biological illness and psychiatric illness. However, as with Brown's model, although conceptually a distinction has been made regarding the type of attention involved, how body-focused attention and attention to high-level beliefs may interact, and how this may be distinguished experimentally is not clear.

1.6.9 *Links with the wider literature*

The concept of top-down simulation of bodily states has also been discussed in the wider literature on decision-making. Damasio's somatic marker hypothesis (SMH; Damasio et al., 1991; Damasio, 1996) and Paulus' ideas around discrepancy detection (Paulus, 2007; Paulus & Stein 2010), for example, both propose that top-down processes are key to understanding how the brain makes predictive models about changes it expects within the body. Both Damasio and Paulus propose that these top-down generated predictive models play a key role in decision-making processes (See Dunn, Dalgleish & Lawrence, 2006 for a critical review of the SMH).

The SMH was developed in order to explain why patients with damage to ventromedial prefrontal cortex (VMPFC) display deficits in emotional and everyday decision-making. Damasio proposed that somatic marker biasing signals from the body are

coded in and regulate the emotional network of the brain, particularly within the VMPCF. Somatic marker signals are thought to play a key role in guiding effective decision-making particularly when under conditions of uncertainty or complexity (Dunn, Dalgleish & Lawrence, 2006). Damasio proposed that somatic markers may be generated from the body and represented in the emotional network, the so called 'body loop'; or they may be generated via the brain's representation of the bodily reaction expected to take place, the so called 'as-if loop'. The as-if loop therefore represents a top-down generated somatic marker which is then coded in the emotional network and guides decision-making. The 'as-if loop' effectively bypasses bottom-up information from the body in order to guide decision-making.

Similarly, Paulus has suggested that the decision-making dysfunctions characteristic of psychiatric populations are largely due to attempts to regulate an unstable homeostatic balance (Paulus, 2007). Making particular reference to anxiety and depression Paulus and Stein (2010) have hypothesised that altered interoceptive states may lead to the development of unstable interoceptive schemas that increase predictive uncertainty. In order to regulate altered interoceptive states and reduce uncertainty individuals increase top-down control via predictive models that seek to minimise discrepancies. Thus both Damasio and Paulus hypothesise that top-down processes may play an important role in the perception and regulation of physical states, which are considered to play a key role in decision-making.

1.7. Areas of research

The theories discussed above all offer hypotheses regarding the development and maintenance of physical symptoms in the absence of organic pathology. Common to all of these models, is the proposition that, attentional and perceptual processes are central to the development and maintenance of such symptoms.

Health anxiety and symptom reporting are highly related constructs. In the models discussed above, health anxiety is generally considered to be a driver of the attentional and perceptual processes implicated in the development and maintenance of symptoms. (e.g. Barsky & Wyshak, 1990). Typically health anxiety has been associated with the misattribution of inert sensations and symptoms as signs of disease, that is, 'hypochondriachal somatisation'. However, whether the same or different processes underlie the symptoms associated with hypochondriachal, functional or presenting

somatisation is unclear. The models discussed above typically identify two main attentional and perceptual processes: attention and somatic awareness, as being central to the development of symptoms. However, little is known about the relationship between attention, somatic awareness, symptom reporting and health anxiety. The lack of empirical evidence regarding these hypothesised relationships has been the main motivation for the work presented in this thesis.

1.8. Structure of the thesis

In the following chapter, the concepts of attention and somatic awareness will be further elaborated and evidence pertaining to their relationship with both symptom reporting and health anxiety will be discussed. A critical analysis of the paradigms used to measure both constructs will be made, and methods that could be used to extend research in this area will also be identified. Models of symptom reporting and health anxiety incorporating both attention and somatic awareness will be stated, and testable hypotheses will be derived.

The research described in this thesis was carried out in both student (Chapters 3 and 7) and primary care samples (Chapters 4, 5 & 6). In Chapter 3, paradigms assessing attention and somatic awareness were piloted and further developed. Chapters 4 and 5 describe a prospective study in which the paradigms outlined in Chapter 3 were applied to a sample of primary care patients. Chapter 6 presents a structural equation modelling analysis of the data collected in the prospective primary care study. Chapter 7 presents a final study employing the same paradigms and a negative mood induction with an analogue sample.

Chapter 2. Attention and somatic awareness: Empirical evidence and methodological considerations

2.1. Defining attention

Attention is an umbrella term that denotes a number of different but related cognitive processes. In cognitive research, attention is understood as the process by which information is selected for *priority processing*. The conscious allocation of cognitive processing resources is typically referred to as *selective attention*, a process engaged to ensure that what has been selected is processed further. We are able to selectively attend to objects, modalities, and spatial locations (Shinn-Cunningham, 2008; Spence & Gallace, 2007; Spence, et al., 1998). The object of our attention receives processing benefits, which have been demonstrated via behavioural paradigms in the form of faster reaction times, or lower error rates.

Not all selection is consciously controlled. We are constantly receiving sensory information and much of what is selected for perception is done at a preconscious level. This type of selection is therefore experienced as effortless and automatic. Thus, selective attention is sometimes used to refer to the process by which sensory inputs are selected for perception, and sometimes to the conscious allocation of cognitive processing resources. Both types of selection refer to the selection of information for further processing, however, selective attention is under direct conscious control, while preconscious selection is not. In this thesis 'selective attention' will be used to refer to the conscious control of perceptual selection (e.g. Spence & Driver, 1997), whilst 'selection' will be used to refer to the pre-conscious analysis and selection of sensory inputs (e.g. Broadbent, 1977). By engaging selective attention we are consciously biasing the selection process to particular sensory inputs.

What we perceive is a product of both selective attention and selection. Both processes interact to determine the focus of perception. Selective attention and selection are influenced by a combination of bottom-up and top-down factors. Bottom-up factors relate to aspects which can be external or internal to us, such as sudden onsets (e.g. loud noises or unexpected pain) that are able to exert an automatic (unconscious) effect on our focus of attention. Bottom-up effects are referred to in the literature on attention as 'exogenous' and are thought to involve the parietal lobe, the pulvinar, and the superior colliculus (Posner, Petersen, Fox, & Raichle, 1988). Top-down factors relate to our goals,

thoughts, memories and emotions and can exert influence consciously on selective attention, and pre-consciously on the selection process. Top-down effects are referred to as 'endogenous' and involve the anterior regions of the brain, in particular the anterior cingulate cortex (Pardo, Pardo, Janer, & Raichle, 1990).

Experimental evidence has demonstrated that both exogenous and endogenous processes determine the object(s) of attention; however, they are not processes which are entirely independent of one another (Cowan, 1997). Exogenous processing can be influenced by our goals; for example, if an individual is endogenously directing attention to a particular task, sudden onsets that would otherwise trigger exogenous processing may not be selected for attention (Theeuwes, 1991). Task-relevant stimuli will, however, be more likely to trigger exogenous processing than task-irrelevant stimuli (Yantis & Jonides, 1990). Novelty and unexpectedness (both requiring endogenous, high-level processing) also influence focus, which further demonstrates how both endogenous and exogenous attention interact (Corbetta & Shulman, 2002). This highlights how exogenous attention can be influenced by both bottom-up and top-down factors, and also how top-down factors can work consciously and pre-consciously on perception. In this thesis, the term 'endogenous' will be used when referring to the consciously controlled focussing of attention and the term 'exogenous' will refer to stimulus-driven focussing of attention.

2.2. Attentional biases in psychological theories of MUS

The psychological theories discussed in the previous chapter hypothesise that attentional abnormalities are central to the development and maintenance of physical symptoms. Dissociative models propose more general attentional deficits, which affect the integration of all types of sensory information with conscious awareness (Janet, 1907; Khilstrom, 1992). Biopsychosocial models generally propose a body-focused attentional bias and specific biases for illness-related information (Pennebaker, 1982; Barsky, & Wyshak, 1990; Cioffi, 1991; Rief & Barsky, 2005). Later cognitive-attentional (Brown, 2004) and neurobiological models (Edwards et al., 2012) have implicated attentional biases specifically for symptom representations or abnormal illness beliefs, rather than attention to the body per se. However, as Miles (2009) has noted, the specific form these attentional biases take has often not been stated in a way that allows testable hypotheses to be derived.

Most biopsychosocial models conceptualise attentional biases as being either general or specific, without considering the attentional level at which they operate

(exogenous or endogenous). Consequently, this prevents specific predictions being made about the nature of attentional biases. Pennebaker's (1982) model suggests that physical symptoms are generated by increased attention to the body (general bias) and increased attention to symptoms (specific bias). In this model, increasing attention to the body increases the volume of somatic information in conscious awareness. Specific attention to symptom-relevant somatic information then further changes the content of conscious awareness. Barsky and colleagues (Barsky et al., 1988; Barsky & Wyshak, 1990) propose an attentional hypervigilance for sensations (general bias) and a specific bias for interpreting those sensations as symptom-consistent in those with hypochondriasis. Rief and Barsky's (2005) model hypothesises that attention to the body decreases the pre-conscious filtering mechanism (general bias affecting selection), which in turn increases the volume of sensory information available in somatic awareness. Similarly, Cioffi's (1991) model proposes that self-focused attention makes more information available (general bias affecting selection), but emphasises that a specific bias affecting selective attention determines the relevance of the somatic information, which further influences perception.

The distinction between general and specific attentional biases can be related to exogenous and endogenous attention. A general bias for the body would suggest a relatively automatic or exogenous attentional bias, whilst specific biases for symptom/illness related information may reflect more endogenous attentional processes. Later models have been more specific in their predictions. An exogenous attentional bias is hypothesised in the Brown (2004) model, where more active symptom representations are automatically selected to organise sensory information. Similarly Edwards et al., (2012) propose that higher level predictions (e.g. endogenous processes) automatically bias predictions lower down the hierarchy (e.g. exogenous processes), which organise incoming sensory data.

An important question, however, is what is meant by attention to the body in these models? Since most models assume that attention to the body increases the volume of sensory information, we can infer that attention to the body generally refers to a focus on somatosensory signals. However, as Cioffi (1991) has highlighted, attention to the body is not necessarily pathogenic. Indeed, both Cioffi and Brown suggest that those with MUS may focus on interpretations or cognitive representations of symptoms or sensations, rather than the features of somatosensory signals themselves. In this way, attention to the body could also represent attention to top-down cognitive representations of the body, symptoms

or illness with little attention to bottom-up sensory experience. Similarly, Edwards et al. propose that excessive attention is afforded to abnormal illness beliefs, rather than the features of somatosensory signals. Brown has suggested that both attention to and away from the body may be important. A hypervigilance for sensations, coupled with subsequent avoidance of sensations, may maintain a reliance on top-down representations of the body, making the experience of distortions in awareness (i.e. MUS) more likely.

In contrast, dissociative theories propose a general attentional dysfunction as central to the development of MUS. Janet's (1907) influential model hypothesised a narrowing of attention, under conditions of threat, and a general problem integrating sensory information with conscious awareness. Later, Ludwig (1972) similarly proposed an attentional dysfunction, in this case involving the inhibition of sensory information. More recently, Khilstrom (1992), specifically referring to conversion disorder, has proposed a high level attentional deficit, but intact low level processing. A deficit such as this might suggest a problem processing *all* types of sensory information, rather than specifically somatic information or illness-related information. Dissociative theories hypothesise that exogenous processing remains relatively intact (e.g. the selection and encoding process). However, problems arise later with the integration of information into conscious awareness, so that deficits operate at a relatively late stage of perceptual selection prior to conscious awareness. A major problem with testing hypotheses derived from dissociative theories is that they do not make specific predictions about the kind of attentional deficits expected in those with MUS (Brown, 2004). Instead, they suggest a more general problem with attention rather than a specific deficit or bias for a certain type of sensory information (e.g. somatosensory). Conversely, biopsychosocial (Pennebaker, 1982; Barsky et al., 1988, 1990; Rief & Barsky, 2005), cognitive-attentional (Brown, 2004), and neurobiological models (Edwards, 2012) propose that attentional deficits operate at both early stages of perceptual selection and later stages of perceptual processing.

Broadly speaking, models either propose both exogenous and endogenous attentional biases (e.g., attention to the body and for illness related information), or they propose intact exogenous processing and a more general endogenous problem with the integration of stimuli into awareness. Although attentional distinctions such as these have not been drawn in most models, experimental research has drawn such distinctions in terms of the paradigms used to measure attention. Experimental research has investigated the relationship between attentional processes, symptom reporting MUS and health anxiety

using a variety of behavioural paradigms. This research has been conducted with diverse populations, from those diagnosed with somatoform and related disorders, functional somatic syndromes and to those identified using scores on questionnaire measures of symptom reporting. The heterogeneous nature of both the paradigms and the populations investigated make it difficult to draw firm conclusions about the generality of the attentional deficits identified. In the following section, the evidence pertaining to a general attentional deficit as hypothesised by dissociative models will be discussed.

2.3. Evidence for a general attentional deficit

Dissociative models have generally been concerned with explaining conversion (i.e., 'pseudoneurological') symptoms, such as non-organic blindness. Attentional explanations, which posit high-level inhibition of sensory information, seem sensible for this type of MUS. Accordingly, much of the research in this area has been conducted with conversion patients.

Direct behavioural evidence has shown that conversion patients with non-organic blindness, sensory loss or deafness perform significantly below chance on detection tasks, indicating that stimuli are still being perceived at a level that is able to influence task responses (Grosz & Zimmerman, 1965; Pankratz, Fausti, & Peed, 1975). In addition, ERP (event-related potential) studies with conversion patients have also found early sensory processing to be normal (e.g. normal early evoked potentials), but with an altered later P300 component (Fekuda et al., 1996; Lorenz, Kunze, & Bromm, 1998). The P300 component is thought to reflect higher cognitive responses to unexpected or salient stimuli.

These findings implicate the pre-conscious selective attentional gating of processed information *prior to* the generation of conscious awareness in patients with conversion disorder (Brown, 2004). These studies do not, however, directly show whether deficits in preconscious screening reflect abnormalities in endogenous or exogenous attention. Few studies have employed experimental paradigms which directly assess endogenous and exogenous attention in conversion disorder.

2.3.1. *The cue-target paradigm*

In the general literature on attention, a well-validated approach known as the cue-target paradigm (Posner, 1980) has been employed to measure exogenous and endogenous attention. The cue-target paradigm typically involves the presentation of a visual cue,

which focusses attention, followed by a visual target, which must be responded to. In the endogenous condition the cue is a centrally presented arrow pointing left or right, either correctly predicting the position of the target (valid), or incorrectly predicting the position of the target (invalid; see Figure 2.1 below). The interpretation of the direction of the cue requires central processing and can be ignored if it is not found to be useful. In the exogenous condition, a peripheral cue appears in either the same place as the target (valid), or in an opposite location (invalid; see Figure 2.2 below). This type of cue automatically attracts attention (without requiring central processing) and cannot be ignored, unlike the central cue. In both conditions, cues which correctly predict the target location typically result in a reduction of reaction times (RTs), whereas invalid cues typically result in increased RTs (Posner, 1980). By comparing RTs of valid and invalid targets, the spatial distribution of attention can be estimated. At short stimulus onset asynchronies (SOAs: the time between the presentation of a cue and the presentation of the target), RTs are typically quicker when a cue and target are presented at the same location (valid) than at an opposite location (invalid). In the exogenous condition, this reflects automatic attention to the cued location and is known as a 'cueing effect'.

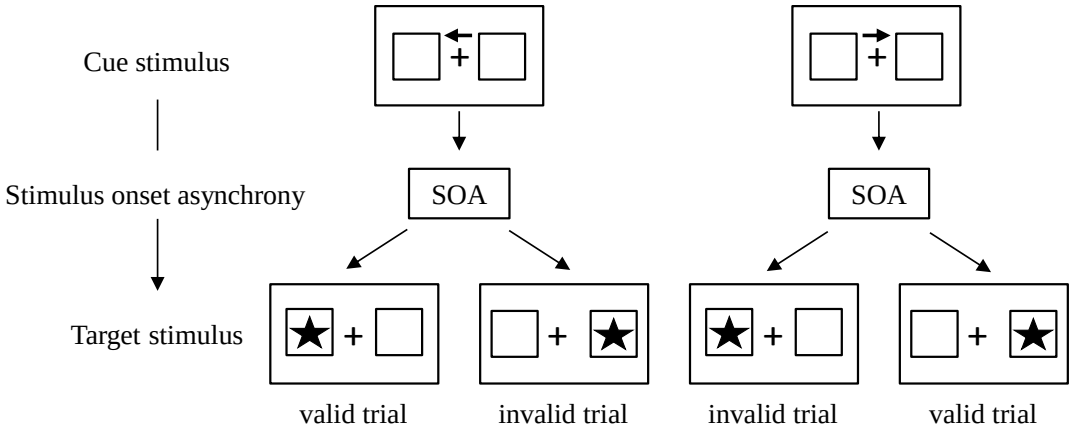

Figure 2.1 The possible trial combinations in an endogenous cue-target task (Posner, 1980)

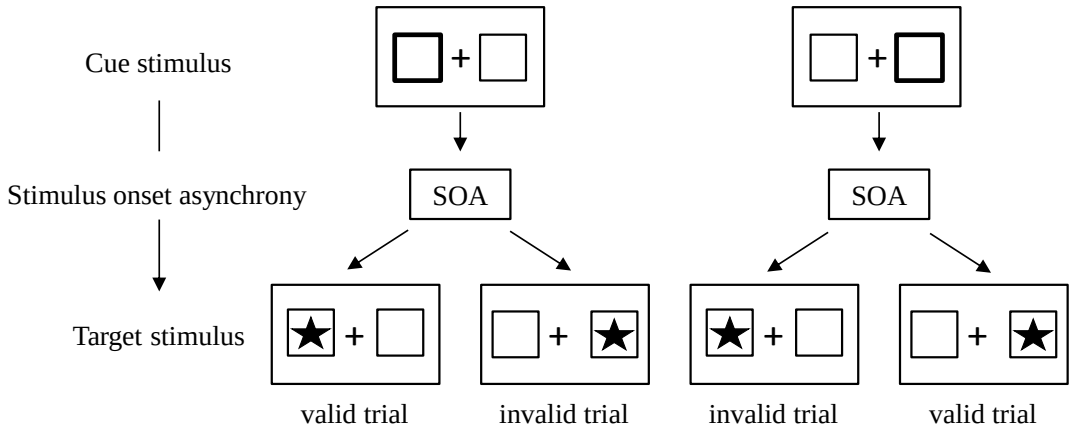

Figure 2.2 The possible trial combinations of an exogenous cue-target task (Posner, 1980)

'Inhibition of return' (IOR; Posner et al., 1985; Klein, 2000) occurs once attention has disengaged from the cued location. Therefore at longer SOAs, participants are slower to respond to valid than invalid targets . *Exogenous* cueing effects are greatest at SOAs of 70-150ms and decrease thereafter due to IOR. In *endogenous* tasks, the cueing effect builds up over a longer time to around 300ms and decreases thereafter (again due to IOR). IOR is thought to be an important mechanism whereby the attentional system is able to favour novel spatial locations by inhibiting ones which have recently been scanned, and is thought to reflect a strategy for efficient visual search (Klein, 1988). In the exogenous condition, both cueing effects and IOR are thought to represent relatively automatic processes. However, IOR can be overridden by higher-order processes such as those hypothesised to operate in MUS. In the endogenous condition, cueing effects are considered to represent endogenous processing, because of the level of processing needed to interpret the direction of the arrow.

A study by Roelofs et al. (2003) employed both endogenous and exogenous conditions of the cue-target paradigm with patients with conversion paresis (unexplained limbweakness) and controls. Both verbal and manual (i.e. with an affected/unaffected limb) response versions of this task were employed. When responding verbally, patients showed decreased endogenous cue effects at an SOA of 150ms. In the exogenous condition, they found early cue effects to be normal. However, whilst the controls displayed IOR at an SOA of 550ms, the patients did not, indicating a deficit in disengagement (i.e. reduced IOR) in conversion patients. When responding with the

affected limb, comparable effects were found. Interestingly, the affected limb displayed a greater deficit in disengagement than the unaffected limb. The results for the affected limb were similar to the verbal response condition. This suggests that the high-level deficit involved was not a generalised attentional disturbance.

The diminished IOR effects on the exogenous task suggest that higher-order attention may have led to slower disengagement from the cued location. Roelofs et al's. study provides more direct support for intact exogenous processes and endogenous deficits in conversion disorder. An absence of IOR is not unique to conversion disorder, but has also been found for patients with schizophrenia (Carter, Robertson, Chaderjian, O'Shara-Celaya, & Nordahl, 1994; Huxley & Wexler, 1994).

The methods employed in this study, however, are open to criticisms made in the attention literature regarding the cue-target paradigm in general. Firstly, the use of a detection task means that spatial effects could be attributable to non-attentional confounds, such as response priming (Spence & Driver, 1997). Secondly, arrow cues have been shown to lead to automatic shifts in attention, meaning that associated cueing effects cannot be considered as demonstrating purely endogenous attention (Tipples, 2002). In addition, the small sample size may have led to any more subtle differences between controls and patients being overlooked, and the cross-sectional design does not allow inferences about cause and effect to be made.

This study does, however, provide greater insight into the nature of attentional deficits in conversion disorder, and lends support to the hypothesised role of endogenous attention in the development of the MUS characteristic of conversions disorders. Whether this evidence can be generalised to more common forms of MUS or symptom reporting in general is unclear, however. Brown (2004) and Edwards (2012) have suggested similar mechanisms may underlie both; others would disagree and see very different mechanisms as responsible for conversion symptoms and the more common forms of MUS (e.g., Kihlstrom, 1992).

2.4. Specific attentional biases

2.4.1. *Attention to the body*

A number of studies involving healthy participants have indicated that directly focusing attention on the body increases physical symptom reports (e.g. Pennebaker, 1982;

Schmidt et al., 1994). Studies have also demonstrated that distraction decreases the perceived intensity and unpleasantness of painful sensations (Lautenbacher, 1998); however, other studies have not (Haenen et al., 1996). Interestingly, health anxious individuals may report more distress and physical symptoms when focussing away from their bodies, than when they are focusing on their bodies (Hadjistavropoulos et al., 2000). How participants interpret such instructions, and the processes involved in focussing on and away from the body in these experiments is unclear. Participants may be focusing on the concrete physical components of somatosensory signals, or on the interpretation and meaning of those signals, or indeed on cognitive representations of sensations or the body. What processes participants are engaging in when attending away from the body is similarly unclear. Therefore, studies that have manipulated attention towards and away from the body are unable to provide direct support for the central role of a body-focused attentional bias.

2.4.2. *Questionnaire measures and somatosensory amplification*

Studies have found associations between symptom reporting and questionnaires measuring self-focused attention as a personality trait (Barsky et al, 1988; Shields, Mallory, & Simon, 1989; Kolk et al., 2003). Most of the evidence linking self-focused attention and symptom reporting has come from research employing the somatosensory amplification scale (SSAS; Barsky, Wyshack, & Klerman, 1990). This ten-item questionnaire asks respondents to rate on a five point scale (‘not at all true’ to ’extremely true’) how bothered they are by a number of bodily sensations (e.g. I hate to be too hot or too cold). SSAS scores have been found to be higher in patients with IBS (Jones, Wessinger, & Crowell 2006), functional dyspepsia (Jones & Maganti, 2004), chronic pain (Ak, Sayar, & Yontem, 2004) and somatoform disorders (Bailer, et al., 2005; Bailer, et al., 2007), in comparison to controls.

It has been assumed that the SSAS is measuring attention to the body due to its association with symptom reporting and hypochondriasis (Pennebaker & Watson, 1989). However, somatosensory amplification involves not just the tendency to selectively attend to the body, but the tendency to experience sensations as unpleasant, or to interpret them as negative. In this respect the SSAS has much in common with NA; indeed, the SSAS phrases questions in such a way that it may simply be measuring how unpleasant people find bodily sensations rather than how much they focus on their bodies (Miles, 2009).

Since NA is known to have an effect upon the reporting of symptoms, and studies using the SSAS have not controlled for NA, it is possible that the relationship between SSAS and symptom reporting is completely mediated by NA.

Regardless of what dimension the SSAS is tapping, questionnaire measures are unable to directly measure attentional or perceptual processes. Furthermore, studies investigating heartbeat detection accuracy and its relationship with the SSAS, have not found SSAS scores to be associated with increased accuracy in clinical and non-clinical samples (Barsky et al., 1995; Aronson et al., 2001). In fact Mailloux and Brener (2002) found that more accurate heartbeat detectors had lower scores on the SSAS than their less accurate counterparts. This suggests that either an attentional bias for the body in high SASS scorers does not lead to greater sensitivity for somatic sensations, or that the SSAS does not measure attention to the body at all.

2.5. Attentional bias for illness or threat related information

2.5.1. *Emotional Stroop tasks*

More direct evidence for attentional biases has come from emotional Stroop tasks. In emotional Stroop tasks participants are asked to name the colour, as quickly as possible, of a series of words. Performance time on neutral word trials is compared with emotional word trials, and an attentional bias is inferred if individuals take longer to colour name emotional words than neutral words. Thus the emotional content of the word is thought to have captured attention when colour naming latencies are increased.

Evidence from emotional Stroop colour naming tasks suggests that high symptom reporters' colour naming latencies are increased when words are health related (Lupke & Elhert, 1998) and symptom related (Witthöft et al., 2006). However, a study by Moss-Morris and Petrie (2003) did not find greater emotional Stroop interference for somatic words in CFS patients compared to controls. Lim and Kim (2005) employed a modified Stroop paradigm with SFD patients and controls. Participants were presented with words subliminally (words presented too rapidly to be consciously processed) or supraliminally (words presented for a sufficient duration to allow conscious awareness). They found that those with SFD displayed longer colour naming latencies for supraliminally presented physical threat words compared to other word types, but not for subliminally presented words. The authors interpreted the results as suggesting a more endogenous processing

bias. Interestingly, a study by Afzal, Potokar, Pobert and Marcus (2006) employed a similar modified Stroop paradigm with IBS patients and healthy controls but showed the opposite pattern; IBS patients only exhibited a Stroop effect for subliminal IBS-related words, whereas controls only showed a Stroop effect for supraliminal IBS words. The authors interpreted this finding as suggestive of a very early processing bias operating outside of conscious awareness, while the lack of a processing bias for supraliminal words was interpreted as suggesting that IBS patients were able to override the processing bias when words were presented for sufficient time (i.e. early facilitation and no delayed disengagement). For healthy controls, the threating and unfamiliar nature of the words may have captured attention more strongly only once they were consciously aware of them. This paradigm, however, does not directly measure facilitation or disengagement, thus the authors' interpretation remains a tentative hypotheses. Also IBS related words are likely to be more familiar to IBS patients, therefore the subliminal effects observed may be due to familiarity rather than saliency. The inclusion of an IBS clinician control group in future research could be used to control for familiarity (Afzal et al., 2006).

Studies investigating chronic pain have also found inconsistent Stroop results. Pearce and Morley (1998) found that chronic pain patients have increased colour naming latencies for pain related words compared to controls. However, other studies have found no such bias (Asmundson, Wright, & Hadjistravropoulos, 2005; Pincus, Fraser, & Pearce, 1998), or have only found within-group associations (Andersson & Haldrup, 2003; Beck, Freeman, Shipherd, Hamblen, & Lackner, 2001; Crombez, Hermans, & Adriaensen, 2000; Snider, Asmundson, & Wiess, 2000). However, a meta-analysis revealed significant differences between chronic pain patients and controls for both sensory and affective pain-related words, indicating that chronic pain patients selectively attend to such words to a greater extent than healthy controls (Roelofs, Peters, Zeegers, & Vlaeyen, 2002).

Importantly, many of the Stroop studies outlined did not control for current anxiety, so the observed effects may be due to a general threat perception effect or due to anxiety (Eysenck & Calvo, 1992). Neither did they control for health anxiety, which has been found to be related to Stroop effects for illness-related words (Owens et al., 2004), irrespective of symptom reports (Karademas et al., 2008).

Ultimately, emotional Stroop effects can only ever demonstrate that performance is affected when processing health or threat related stimuli, which could be due to avoidance, a bias towards processing words more deeply (de Ruiter & Brosschot, 1994), a cognitive conflict caused by the perceived threat value of the word (Williams et al., 1996), or

impaired processing of the word due to increased levels of general anxiety (Eysenck et al., 2007). As a result, emotional Stroop paradigms only represent a proxy measure of attentional biases for illness related information.

2.5.2. *Dot-probe tasks*

The dot-probe task is another paradigm that has been used to assess the effect of threat on visual attention, in MUS and health anxiety (see Figure 2.3 below; Macleod et al., 1986). Initially, a fixation cross is presented, followed by a trial in which a pair of stimuli are presented simultaneously above and below the initial fixation point for a predetermined length of time, usually around 500ms. Typically, the stimuli are pairs of words, however picture stimuli have also been used. Experimental trials feature one emotional/threatening stimulus and one neutral stimulus. Following this presentation both stimuli are removed and then a visual probe (usually a dot) replaces one of the two stimuli. In congruent trials the dot replaces the emotional/threatening stimulus, while incongruent trials feature the probe replacing the neutral stimulus.

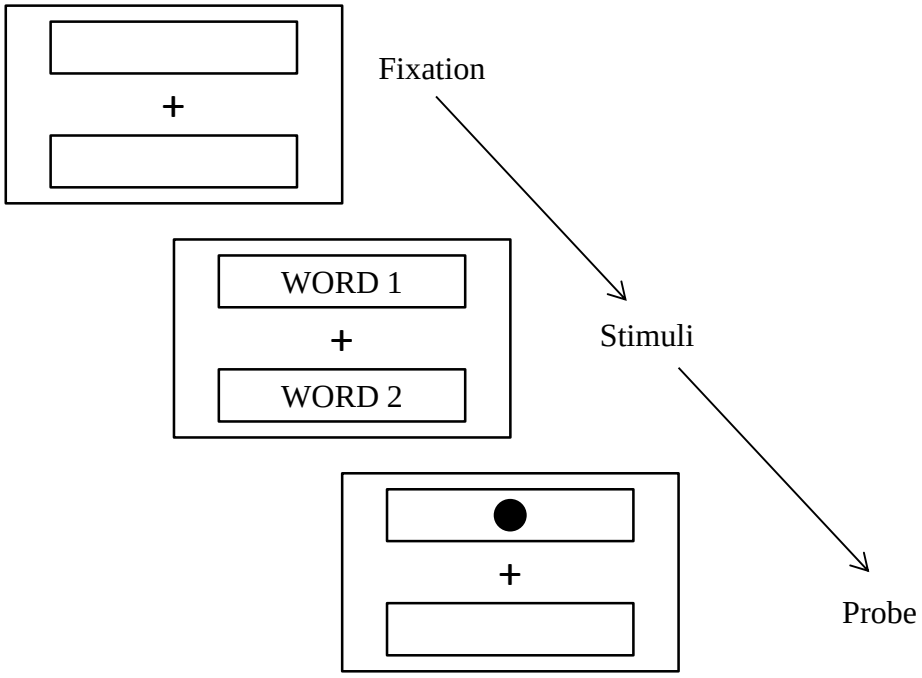

Figure 2.3 The dot-probe task

Participants are required to indicate the location or type of probe as quickly and accurately as possible usually via a keyboard. As in the cue-target task, RTs for probes are typically faster when trials are congruent (cued) than incongruent (un-cued). Averaged

response times are calculated for congruent and incongruent trials, which are then used to calculate attentional bias. A positive score indicates a shift of attention towards the location of the threatening stimulus, relative to the neutral stimulus, thus indicating a bias for threat. A negative score indicates a shift in attention away from the threatening stimuli towards neutral stimuli, indicating attentional avoidance. A zero score indicates no evidence of bias or avoidance. Although bias for threat is thought to result from hypervigilance for threat (i.e. faster response times on congruent trials), such a bias may also result from difficulty disengaging from threat (i.e. slowed response times for incongruent trials). Therefore, in some studies, separate measures for congruent and incongruent trials have been calculated (Koster, Crombez, Verschuere, & De Houwer, 2004). Negative scores on the congruency measure indicate hypervigilance for threat whilst positive scores on the incongruency measure indicate difficulty disengaging from threat. However, an incongruency effect may not simply reflect delayed disengagement, it may also reflect a general slowing of motor responses due to the presence of threat (Mogg, Holmes, Garner, & Bradly, 2008).

Although stimuli have typically been presented for a relatively short period (300-500 ms), it is possible to present cues for longer (i.e. 1250ms). Effects found at short presentation periods are thought to reflect relatively exogenous processes (Gamble & Rapee, 2009), whereas effects found at longer presentation periods reflect more endogenous processes (Donaldson et al., 2007). However, few studies have utilised longer presentation periods. Table 2.1 below, displays the findings of both linguistic and pictorial dot-probe tasks for patients with functional syndromes, SFD and health anxiety.

Table 2.1 The results of linguistic and pictorial visual dot-probe tasks for patients with functional syndromes, SFD and health anxiety (between-groups (BG) and within groups (WG).

Authors	**Desig-n**	**Stimuli**	**Presen-tation length**	**Patient group**	**Hyper-vigilance**	**Avoidance**	**Delayed disengage-ment**
Asmundson, Carlton, & Ekong, 2005;	BG	Word	500 ms	Chronic headache vs control	No	No	No
Asmundson et al., 1997	BG	Word	500 ms	Chronic pain vs control	No	Yes (only for chronic pain patients with low anxiety sensitivity)	No
Asmundson, Wright, et al., 2005	BG	Word	500 ms	Chronic pain vs control	No	No	No
Roelofs et al., 2005	BG	Word	500 ms	Chronic lower back pain vs controls	No	No	Yes
Haggman, Sharpe, Nicholas, & Refshauge, 2010	BG	Word	500 ms	Acute vs chronic lower back pain vs controls	Yes, but no difference between acute and chronic pain	No	No
Witthoft et al. 2006	BG	Word	500 ms	SFD patients vs. controls	No	No	No
Liossi, Schoth, Bradley, &Mogg, 2009; Liossi, White, & Schoth, 2011	BG	Word	500 ms & 1250 ms	Chronic headache vs. control	500 ms: No; 1250 ms: yes.	No	500 ms: No; 1250 ms: yes
Schoth & Liossi, 2010	BG	Picture	500 ms & 1250 ms	Chronic headache patient versus controls	Yes	No	Yes
Roelofs, Peters, Fasseart, & Vlaeyen, 2005	BG	Picture	500 ms	Chronic pain patient vs controls	No	No	Yes, not related to fear of movement
Khatibi et al., 2009	BG	Picture	500 ms	Chronic pain vs controls	No	Yes (only for high fear of re-injury irrespective of group status)	No
Hou et al., 2008	BG	Picture	500 ms	CFS patient vs controls	No	No	Yes
Lees, Mogg, & Bradley, 2005	BG	Picture & word	500 ms & 1250 ms	High vs. low health anxiety	No	No	No
Witthöft & Jasper, 2011	WG	Picture	175 ms & 500 ms	Health anxiety	Yes at 175 ms, no at 500 ms	No	Yes at 500 ms and no at 175 ms

The results of linguistic dot-probe tasks suggest that those with MUS do not show an exogenous hypervigilance for threatening words. There is, however, some evidence to suggest that they have problems disengaging from threatening words or a greater slowing of RTs in response to threatening words. There is also evidence to suggest a more endogenous hypervigilance for threatening words at least for chronic pain patients.

The results of pictorial dot-probe tasks suggest both exogenous and endogenous attentional differences. Hypervigilance for, avoidance of, and delayed disengagement from threat have all been demonstrated. All the pictorial dot-probe studies, with the exception of Witthöft et al., (2006), Hou et al., (2008), Lees et al., (2005), and Witthoft and Jasper (2011), havebeen conducted with chronic pain patients, however. It is not certain how generalizable the results of these studies are to those who report other types of MUS. Further dot-probe studies are required with more diverse MUS patients before firm conclusions can be drawn about threat-related attentional biases in other functional syndromes and somatic disorders. The majority of these studies have also employed between-group designs; employing correlational designs would reveal whether individual differences in hypervigilance, avoidance, and disengagement have a linear relationship with symptom reporting more generally. Indeed, the results of Witthöft and Jasper (2011) suggest that both hypervigilance and disengagement are linearly associated with health anxiety. However, it is unknown whether attentional processes such as these are implicated in the experience of hypochondriachal somatisation, since symptom reporting was not measured in this study.

The research discussed so far has only assessed attentional effects within the visual modality. Consequently, this does not provide direct evidence for abnormalities in attention to the body or for a body-focused attentional bias. Abnormalities in attention to the body or indeed an excessive body-focused attentional bias would be better evaluated by assessing attention within the tactile modality, which is a proximal sense with spatial referents on the body. Few studies have assessed tactile attention in relation to symptom reporting, MUS or health anxiety. How people respond to stimuli on their bodies has received greater consideration in the general literature on attention.

2.6. Tactile attention

2.6.1. *Attending towards the tactile modality*

Important differences have been found between the visual, auditory and tactile modalities in relation to endogenous attention. It is more difficult to shift attention away from the tactile modality once it is focused there compared with shifting attention from auditory or visual modalities (Spence & Gallace, 2007). Spence et al. (2001) have demonstrated that endogenously attending to the tactile modality facilitated responses for tactile targets, compared with attending to visual or auditory modalities. There has been less research regarding whether tactile attention can be captured exogenously. The results of a cue-target study by Turatto, Galfano, Bridgeman and Ultimà (2004) suggest that tactile attention can be directed in a completely exogenous manner. However, more recently Miles, Brown and Poliakoff (2011) have demonstrated that attention cannot be captured to a modality in a purely exogenous manner. It seems attention is only captured to a modality via a combination of both endogenous and exogenous processes.

2.6.2. *Endogenous and exogenous tactile spatial attention*

Research has also demonstrated that people can direct their spatial attention voluntarily to a bodily location and that this facilitates the processing of any tactile stimuli that are subsequently presented there (Spence & Gallace, 2007). Forster and Eimer (2005) have shown that these effects consist of facilitation of responses to tactile stimuli presented on the expected (cued) side and a cost associated with responding to tactile stimuli presented on the unexpected (un-cued) side. Responses to tactile stimuli can also be facilitated by the exogenous orientating of spatial attention to a particular position or part of the body (Spence & McGlone, 2001). However, the time course of attention may be different for tactile stimuli (Spence et al., 2000; Tassinari & Campara, 1996; Miles et al., 2008).

2.6.3. *The effect of threat on tactile spatial attention*

The preferential allocation of visuospatial attention towards the location of a threatening stimulus has been demonstrated using a number of different experimental

paradigms, for example, the visual search task (Ohman et al., 2001), the visual probe task (Mogg et al., 2004), and the visual cueing paradigm (Koster et al., 2006).

Research has shown that visual attention is biased towards the location of threatening words related to illness and physical symptoms (Asmundson et al., 2005; Keogh et al., 2001), towards pictures that show painful events (Roelofs et al., 2005), towards cues that signal impending pain (van Damme et al., 2002), and towards pain (van Damme et al., 2007). Although there is considerable evidence regarding the effect of threat on visuospatial attention there have been only two studies into the effect of threat on tactile spatial attention.

Poliakoff, Miles, Li and Blanchette (2006) demonstrated that the threat value of a visual stimulus can modulate the size of tactile spatial cueing effects. Poliakoff et al. employed a spatial cue-target paradigm with threatening (snakes and spiders) and non-threatening (mushrooms and flowers) picture cues presented close to the participant's hands and tactile targets (vibrations presented to the left and right finger-tips). Perceiving a snake led to a greater early shift in tactile attention to the cued side, relative to the un-cued side. They also found that self-rated fear of snakes was correlated with facilitation at the earliest SOA but not at later SOAs. Facilitation was not found to be correlated with state and trait anxiety, indicating that the effects were not due to general levels of anxiety.

Van Damme, Gallace, Spence et al. (2009) employed threatening body-relevant, threatening body-irrelevant and neutral cues and measured attention to both the tactile and auditory modalities using an un-speeded temporal order judgement (TOJ) task. In the TOJ task, stimuli are presented to both hands and participants judge which was stimulated first. Stimuli must be delivered to the cued hand later, relative to the un-cued hand for the stimuli to be perceived as occurring at the same time. The authors found that tactile attention was biased towards the side of the cue and this bias was significantly greater for threatening body-relevant cues, than for threatening body-irrelevant or neutral cues., Although attention was biased towards the cued side in the auditory modality, this bias was significantly greater for threatening body-irrelevant cues than for body-relevant or neutral cues. These findings demonstrate the modality-specific nature of body-relevant threat cues on tactile modality and body-irrelevant threat cues on the auditory modality. However, this study employed a small (n=13), non-clinical sample and individual differences such as anxiety, health anxiety and symptom reporting (which may affect threat related processing of tactile information) were not measured.

The studies of both Poliakoff et al. and Van Damme et al. demonstrate that the often-observed visuospatial attentional bias for threat can also be observed in the tactile modality and this attentional bias can be modulated by the threat value and specific nature of the stimulus.

2.6.4. *Investigating tactile attention in high symptom reporting, health anxiety and MUS*

Few studies have employed tactile stimuli to investigate attentional biases in high symptom reporting and MUS and there have been none for health anxiety. Employing paradigms which require behavioural responses to stimuli on the body would provide more specific evidence about how attention may be altered in high symptom reporters and those with health anxiety. As noted previously, a number of predictions have been made regarding the type of attentional biases that may operate (See Section 2.2). Many theories have not clearly specified what is meant by attention to the body (which could mean attention to touch, to the body, or to representations of the body) which makes deriving testable hypotheses difficult. The most commonly specified way in which attention to the body has been hypothesised to operate is to alter the perception of physical sensations by increasing the volume of sensations in awareness. This has been proposed to operate either by increasing the perception of sensations *already in* somatic awareness (e.g. Pennebaker 1982, Barsky et al., 1988, 1990), or by lowering the threshold at which sensations enter somatic awareness (Rief & Barsky, 2005). An attentional bias such as this may mean that attention is grabbed more strongly by bodily sensations, that it may take longer to disengage from them or that touch receives preferential processing over other sensory modalities. Threat has been hypothesised to play an important role (Barsky et al., 1989, 1990; Brown, 2004), which may mean that biases only operate in response to threat or only for threat-related sensations. Therefore, the two main studies that have explored attention to touch in high symptom reporters have used threat manipulations.

The effect of threat on spatial attention to touch has been investigated by Brown, Danquah, Miles, Holmes, and Poliakoff (2010), using a tactile cue-target task, with high and low SDQ-20 (a somatoform dissociation questionnaire measuring pseudo-neurological symptoms) scorers. Participants were given a cue vibration to either the left or right hand which was then followed by either a high or low frequency target vibration to either the same or opposite hand as the cue (See Section 2.4 for a full discussion of cue-target tasks).

The SOA between cue and target was varied (SOA: 150 ms, 350 ms and 500 ms) so that the time course of attention to the cue could also be investigated. The participants completed the paradigm before and after they viewed either a distressing film or a neutral film. Low SDQ-20 scorers demonstrated a typical pattern on the task, with a positive cueing effect at 150ms followed by a decrease in cueing effect across SOAs. This pattern was observed in both film conditions, although cueing effects were greater across all SOAs following the distressing film when controlling for trait anxiety, somatosensory amplification and exposure to traumatic events. This demonstrated that, even in healthy participants, attentional cueing effects are influenced by mood. For the high SDQ-20 group, a different pattern of cueing effects was found which were not attributable to between-group differences in covariates. High SDQ-20 scorers who watched the neutral film did not show significant cueing effects until the 350ms SOA and these were still present at the 1000 ms SOA. This pattern of effects suggests both avoidance and delayed disengagement of attention from the cue. However, this effect was found post-film and not pre-film suggesting that task practice played an important role. Following the distressing film, the high SDQ-20 scorers did not exhibit cueing effects at any SOA. That is, following threat, they were less affected by the tactile cue, suggesting avoidance of the body. This effect could not be attributed to a threat-related slowing of RTs as overall RTs were comparable across groups.

These findings cast doubt on theories of MUS that emphasise only a general hypervigilance for somatic information (Kirmayer & Taillefer, 1997). Both hypervigilance for, and avoidance of threat, have been found in anxiety states using visual cue-target tasks (Koster et al., 2006). It has been suggested that hypervigilance and avoidance may be a function of anxiety (Mogg & Bradley, 1998). Early hypervigilance is thought to reflect monitoring for danger to allow rapid mobilisation. Subsequent avoidance is thought to ameliorate threat-induced negative affect. The pattern displayed in this study is consistent with this explanation (Brown et al., 2010a). The results were, however, significant after controlling for both trait and state anxiety, suggesting that a similar process may be involved to that in anxiety, but that anxiety itself cannot explain the findings. Furthermore, cueing effects at the 150ms SOA in high SDQ-20 scorers predicted trauma film intrusions in the week following the trauma film. Whilst avoidance may be a strategy for ameliorating current negative affect it clearly did not result in short-term benefits for participants.

The pattern of results observed in this study does not support the hypothesis that high symptom reporters focus on the body whilst in a negative mood. Whilst in a neutral mood, however, a pattern of early avoidance followed by delayed disengagement was found for high symptom reporters. This pattern suggests exogenous avoidance of the body followed by endogenous problems disengaging from the body. Avoidance of the body following threat induction fits with dissociative theories of MUS. Avoidance of somatosensory information would maintain the flow of dissociated sensory information for the production of MUS. The authors suggest that avoidance of the body may lead to greater reliance on mental representations of bodily state rather than actual bodily state. Delayed disengagement from body-relevant stimuli (i.e. the tactile cue) in a neutral mood state may suggest greater attention to the tactile cue, which is predicted by the Brown model and is considered to contribute to the activation of rogue representations (i.e. MUS).

This paradigm demonstrates how tactile attention in high symptom reporters can be affected by emotional state. However, it does not elucidate whether high symptom reporters are disproportionately body-focused compared with other modalities. The effects found in this study could be attributable to a general spatial attention bias affecting all modalities. Indeed, Roelofs et al. (2003) demonstrated similar effects in the visual modality, suggesting a supramodal deficit in attentional disengagement. In addition, the use of a general trauma film does not allow any specific conclusions to be drawn about which aspects of the trauma film modulated the attentional effects observed (i.e. whether it was body threat or threat more generally that led to avoidance).

A study employing a cue-target paradigm with both tactile and visual stimuli (the modality bias task, MBT) was reported by Brown, Poliakoff, and Kirkman (2007). The authors measured attention following neutral and threatening body-relevant and irrelevant picture cues in non-clinical symptom reporters (students who were high or low somatoform dissociators as measured by the SDQ-20). The tactile stimulus was presented to the index finger of the left or right hand and the visual stimulus was presented from the same spatial location (see Figure 2.4 below). Participants made speeded left/right discriminations for visual and tactile stimuli using foot pedals beneath the left and right toes. The target stimuli were presented either 250ms or 500ms after the onset of a picture cue (200ms). A modality difference score was calculated (visual performance minus tactile performance) to determine the degree of body-focus following each of the picture conditions. Tactile bias is inferred from a positive score which indicates that RTs to tactile targets were quicker and more accurate than RTs to visual targets. Although performance in both modalities

would not be expected to be identical (see Section 2.6.1), such an approach does allow for an evaluation of how the relative balance of tactile-to-visual attention is modulated by the picture conditions and how individual differences in this balance relate to symptom reporting and somatosensory amplification.

There was a tactile bias for both high and low symptom reporters in all picture conditions at the 250ms SOA. Interestingly, there were negative correlations between tactile bias and somatosensory amplification in the neutral-body and threatening-body conditions. This result was unexpected since somatosensory amplification has been typically associated with self-focused attention and therefore facilitation for the tactile modality relative to the visual modality would be expected. The authors suggested that somatic amplifiers may focus less on the tactile modality following exposure to body-relevant information. This interpretation is consistent with research evidence suggesting that high amplifiers are actually worse at heart beat detection tasks than low amplifiers (Mailloux & Brener, 2002). Thus, high amplifiers may inhibit tactile information when exposed to body-relevant information in order to reduce their experience of intense or distressing sensations. However, when SSAS and trait anxiety scores were controlled for, tactile bias following threatening body-relevant pictures was greater for the high SDQ-20 group. Thus, unexplained symptoms were associated with faster performance for tactile targets relative to visual targets following threatening body-relevant pictures, suggestive of a body-focussed bias. The fact that this bias was significantly greater for threatening body-relevant rather than threatening body-irrelevant pictures suggests that the tactile bias was related to the specific content of the pictures rather a general effect of threat. Tactile bias was much lower at the 500ms SOA. The lack of significant effects at the 500 ms SOA suggest that the processing benefits for the high SDQ group were relatively automatic and short lived.

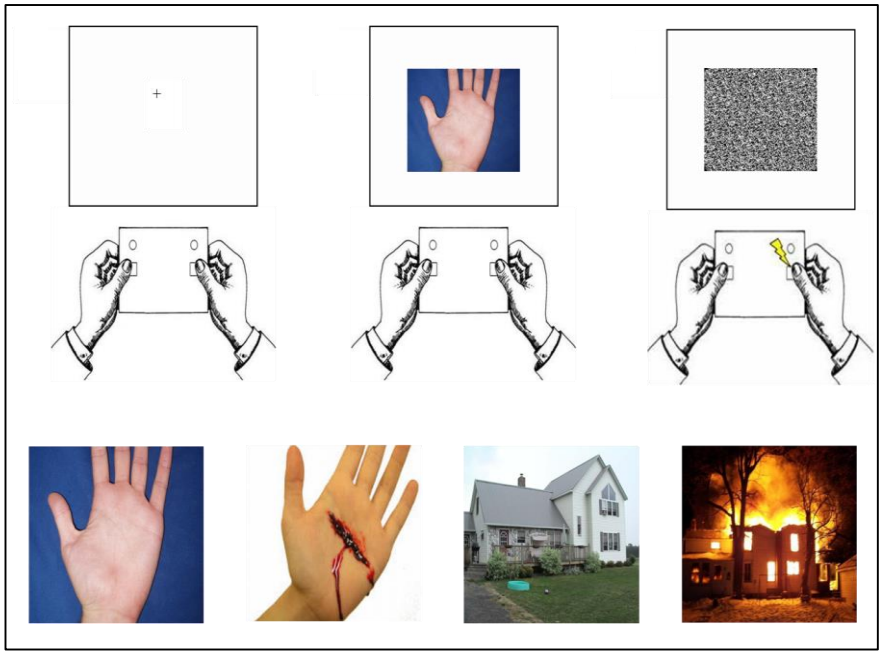

Figure 2.4 The MBT adapted from Brown et al., (2007).

There are, however, some shortcomings to this study. Firstly, visual and tactile responses were not analysed separately, so it is unknown whether symptom reporting is related to performance in individual modalities. Tactile bias could reflect difficulties in disengaging from visual threat as found in previous studies (e.g. Roelofs et al., 2005; Hou, Moss-Morris, Bradley et al., 2008), rather than facilitation of touch per se. This possibility was addressed by the research described in Chapter 3.

The operationalization of MUS as high levels of somatoform dissociation, as measured by the SDQ-20, also poses some difficulties for generalising the results of this study. Whilst the high scorers in this study were comparable to psychiatric outpatients, the SDQ-20 measures a particular type of MUS, namely pseudo-neurological symptoms. These symptoms are typically associated with conversion disorders rather than more commonly experienced MUS such as fatigue and pain associated with functional syndromes and somatoform disorders. Some theorists would argue that the same attentional processes underlie both (Brown, 2004; Edwards, 2012), whereas others would disagree (Kihlstrom, 1992).

The use of tactile stimuli in attentional research marks a move towards measuring attentional processes more relevant to symptom reporting and health anxiety. The methodology used in this task offers a way of assessing the effect of threatening and neutral body-relevant and irrelevant cues upon attention to the body (performance for

tactile targets) and visual attention (performance for visual targets). By comparing tactile and visual performance, a measure of body-focused bias was derived. The overall finding was that high somatoform dissociators display greater tactile bias following threatening body-relevant information. This supports the hypothesis that a body-focused bias may play an important role in the development of MUS. However, the difficulties outlined above make it hard to draw firm conclusions about the nature of the tactile bias and its relationship with non-pseudoneurological MUS. Furthermore, there appears to be a negative relationship between body-focused attention and somatosensory amplification, which has been hypothesised to account for hypochondriachal somatisation. This suggests opposite attentional processes may operate for hypochondriachal versus functional somatisation. Further longitudinal research employing this task and investigating the relationship between attention, general symptom reporting and health anxiety is warranted. In particular, looking separately at visual and tactile performance and controlling for additional relevant factors (i.e. trait and state anxiety) may provide a way of further elucidating the relationship between attention, symptom reporting and health anxiety. To that end, the MBT will be employed in the following empirical chapters as a measure of attention.

2.7. Somatic awareness

Selection and selective attention determine what information in the internal and external environment receives further processing and are therefore closely related to conscious awareness (e.g., Posner, 1994; Velmans, 1996). However, attention and conscious awareness are considered separate entities (e.g., Lamme, 2003), and there is evidence to support this distinction (see Koch & Tsuchiya, 2007 for a review). Somatic awareness specifically refers to our conscious awareness of our bodies. Somatic awareness, like conscious awareness more generally, is driven by a combination of both top-down and bottom-up factors. Subjectively, somatic awareness appears to be an accurate account of our body state, driven only by bottom-up somatosensory signals from within or outside the body. However, there are many examples of disturbances in somatic awareness which suggest our somatic awareness is not as objective as it may seem (e.g. phantom limb syndrome, the rubber hand illusion, phantom vibration syndrome, placebo and nocebo effects; Wall, 1993; Barsky, Saintford, Rogers, & Borus, 2002; Ramachandran & Hirstein, 1998; Botvinick & Cohen, 1998; Rothberg et al., 2010). These phenomena demonstrate

how somatic awareness can be influenced by top-down factors such as selective attention, memory and expectation. As a result, somatic awareness may bear little resemblance to the objective contents of reality.

Dissociative models suggest that MUS are the product of reactivated dissociated memories, which involve trauma-related perceptual information that is held outside somatic awareness. When activated these memories intrude into somatic awareness where they are experienced as a current perception. Similarly, Brown's model suggests that MUS involve the activation of rogue symptom representations stored in the cognitive system. Both models therefore suggest that there is somatosensory information stored in the cognitive system that we may become aware of, if that information is activated. If representations are activated by bottom-up information that is consistent with the representation, then the contents of somatic awareness reflect an objective reality. However, if rogue symptom representations are top-down activated, (i.e. bottom-up information is a poor fit with the selected representation) then a distortion in somatic awareness may be experienced. Brown hypothesises that the tendency to place greater weight on top-down factors relative to bottom-up factors in the creation of somatic awareness varies between individuals (Miles, Poliakoff & Brown, 2011). Brown's model would therefore predict a greater tendency to experience distortions in somatic awareness in those with MUS.

In contrast, biopsychosocial models suggest that the threshold or filtering system which determines what somatosensory information enters somatic awareness is altered via both selection and selective attention. Such alterations can cause an increased amount of somatosensory information to enter somatic awareness. This, coupled with the selective search for illness-relevant information, is thought to increase the number of symptoms in somatic awareness, thus providing evidence of illness. Models such as Pennebaker (1982), Barsky and Wyshak (1990), and Rief and Barsky (2005) suggest that high symptom reporters and highly health anxious individuals have a lower threshold for somatosensory signals (i.e. greater levels of sensitivity in somatic awareness).

2.8. Signal detection theory

Signal detection theory (SDT, e.g., Macmillan & Creelman, 1991) was developed in order to measure the effect of individual differences and the environment on the detection of sensory signals. SDT has typically been employed in yes/no tasks, where the

presence of a sensory signal is varied and participants are asked to decide whether a stimulus has been presented ("yes"), or not ("no"), on each trial. Responses are categorised as in Table 2.2 below.

Table 2.2 Possible responses on yes-no tasks.

	"Yes"	"No"
Signal present	Hit	Miss
Signal absent	False alarm	Correct Rejection

Importantly, SDT utilises both correct and incorrect 'yes' responses (hits and false alarms) in order to derive measures of perceptual sensitivity and response criterion. Without taking into account both correct and incorrect responses when evaluating responses, a distorted picture may emerge.

It is assumed that in both signal present and signal absent trials there is a background of sensory signals (noise) from the sensory system that varies across trials. In signal present trials (signal + noise trials) a stronger sensory signal is elicited compared to signal absent trials (noise only trials). The participant decides whether the trial contained a signal based in part on the strength of the signal relative to the noise. Due to fluctuations in neuronal responses, however, sensory noise is not constant. Keeping the signal constant will not, therefore, result in the same detection rate across trials (Stanislaw & Todorov, 1999). In SDT, the variation in detection rates across trials is conceptualised using probability distributions (see Figure 2.5).

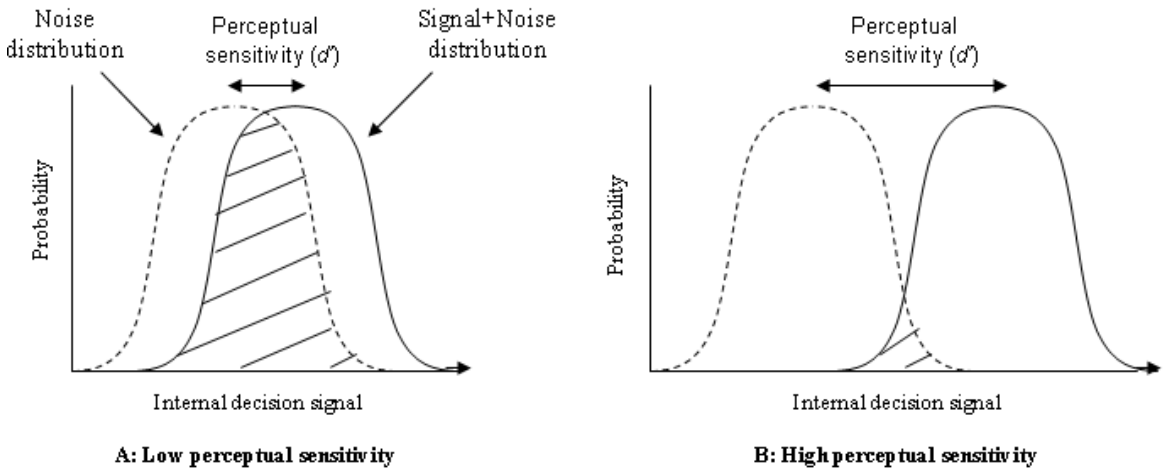

Figure 2.5 *Degree of overlap between signal + noise and noise probability distributions and perceptual sensitivity. A: Low sensitivity increases overlap between signal and noise distributions, increasing the chance of errors. B: High sensitivity reduces overlap between signal and noise distributions, decreasing the chance of errors.*

When there is overlap between the signal + noise and noise distributions (shaded region in Figure 2.5), errors will be made. How much the two distributions overlap depends on the strength of the stimulus relative to the background noise, i.e. an individual's ability to distinguish between signal and noise (perceptual sensitivity known as *d*'). As can be seen in Figure 2.5, the greater the overlap between the distributions, the greater the number of errors, as distinguishing signal from noise is more difficult and provides more opportunities to mistake noise for signal and signal for noise.

Although individual perceptual sensitivity determines whether errors are made, the individual's response criterion (known as *c*) determines the type of errors made (misses or false alarms). Thus, on any trial a participant is comparing the strength of the signal with their response criterion. If the sensory signal is sufficiently strong and greater than their *c*, then participants will respond "yes" (i.e., a signal is present); if the sensory signal is insufficiently strong and below their *c*, the participant will respond "no". A participant with a liberal (low) response criterion will respond "yes" regularly, as the signal strength will regularly exceed *c*. An individual with a stringent (high) response criterion will respond "yes" less often, as the strength of the decision signal will rarely exceed *c*. Figure 2.6 below demonstrates the effect of adopting a liberal or stringent response criterion for the same level of sensitivity.

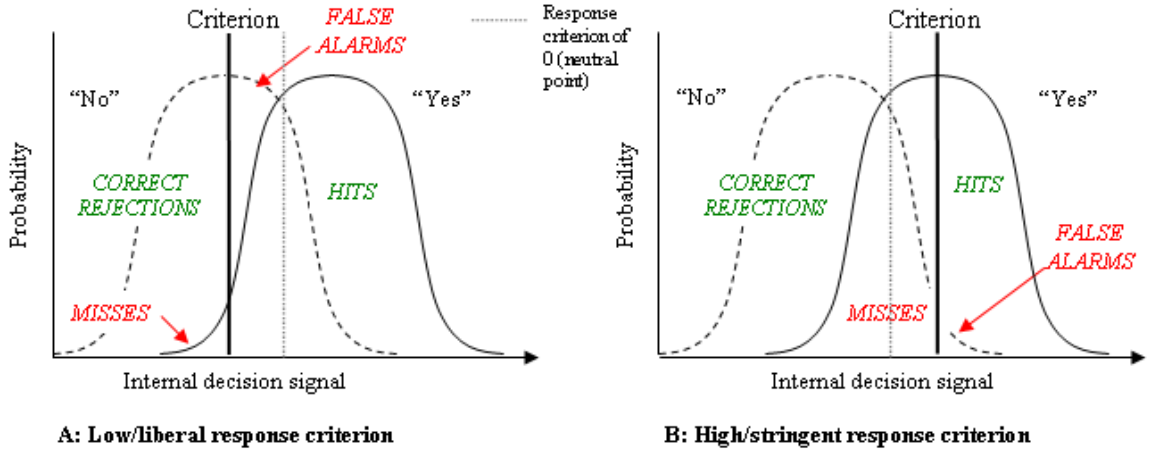

Figure 2.6 *The consequences of adopting a liberal or stringent response criterion.* ***A:*** *An individual with a liberal response criterion responds "yes" frequently, resulting in a high number of hits and a substantial number of false alarms, but a lower number of misses and correct rejections.* ***B:*** *An individual with a stringent response criterion responds "yes" less frequently, resulting in a lower number of hits and false alarms and a higher number of misses and correct rejections (adapted from Mirams, 2013).*

Signal detection statistics *d*' (perceptual sensitivity) and *c* (criterion) are therefore derived from a participant's hit rate (probability of responding "yes" on signal-present trials) and false alarm rate (probability of responding "yes" on signal-absent trials).

2.9. The somatic signal detection task

The somatic signal detection task (SSDT; Lloyd et al., 2008) was developed in order to mimic the occurrence of MUS (as proposed by the Brown model) under experimental conditions. The SSDT follows on from multisensory research indicating that presenting a visual stimulus can increase reports of tactile stimuli both in the presence and absence of a tactile stimulus (Johnson et al. 2006). During the SSDT, participants are asked to judge whether or not they have been presented with a vibration to their fingertip. Vibrations are delivered at the participant's approximate perceptual threshold (such that the correct detection rate is around 40-60%), over a series of trials where the actual presence of the vibration is varied. Perceptual threshold has typically been determined using a yes/no task and manual adjustment of the strength of the tactile stimulus. A task-

irrelevant light is also presented from a spatial location close to the vibration (next to the fingertip) in half of the trials, thus creating four experimental trial conditions: vibration (present; absent) × Light (present; absent).

Participants are asked whether or not they felt the vibration, and can respond in one of four ways: definitely yes, maybe yes, maybe no and definitely no (see Figure 2.7 for schematic of a trial). The four response categories are then collapsed into two response categories: 'yes' and 'no'. Using SDT, participant responses are categorised as hits (vibration present and correct positive response), misses (vibration present and incorrect negative response), correct rejections (vibration absent and correct negative response) and false alarms (vibration absent and incorrect positive response). Participants typically complete two blocks of eighty trials (although in some studies the number of trials has been increased), demarcated by a rest break.

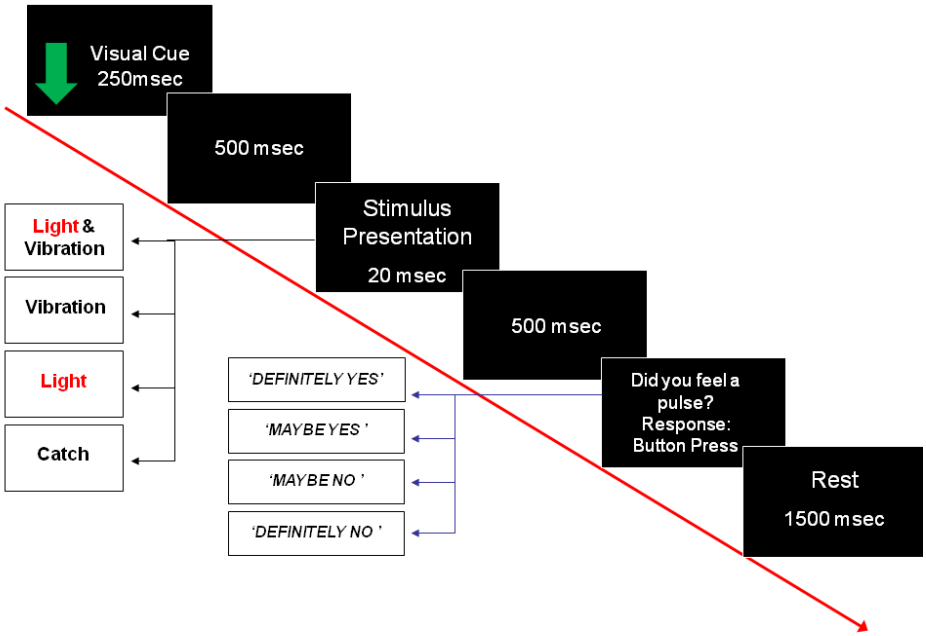

Figure 2.7 Schematic of the SSDT.

In line with previous findings, Lloyd et al. (2008) observed that healthy participants often make false alarms (FAs), that is, they report the presence of a vibration when in fact no vibration has been presented. The authors termed this phenomenon "illusory touch" and demonstrated that illusory touch happens more often when the task-irrelevant light is presented. Lloyd et al. (2008) suggest that illusory touch experiences are analogous to MUS and involve similar mechanisms to those described in the Brown (2004) model. That

is, illusory touch involves the top-down activation of cognitive representations of the touch sensation, which are experienced in somatic awareness as subjectively real experiences of touch (vibration). Illusory touch experiences on the SSDT therefore represent distortions in somatic awareness. SDT is used to further analyse the data from the SSDT, yielding measures of participants' tactile sensitivity (*d'*) and response criterion (*c*). Thus, the SSDT can be used to create bodily distortions and to measure an individual's propensity to experience such distortions, that is, their illusory touch rate (FAs), along with their tactile sensitivity and response bias. Lloyd et al. also found that the presentation of the light led to a significant increase in hit rates and tendency to say yes (response bias). Tactile sensitivity, in contrast, was augmented but not significantly so. Thus, presenting the light enhanced the detection of the tactile stimulus as well as increasing illusory touch reports, though this was because the light resulted in a greater tendency to say yes rather than because of significant changes to perceptual sensitivity.

Sensory signals presented in more than one modality at the same time are often detected more quickly, accurately and at lower thresholds than the same signals presented individually (Hershenson, 1962; Frassinetti, Bologini, & Làdavas, 2002). It has been thought that this effect is due to multi-sensory integration at an early level of perceptual processing. Thus, multisensory integration may explain why hit rates tend to increase in the presence of the light. It also suggests that individuals may rely on visual information when making judgements about somatic events, particularly when that information is ambiguous. A multisensory association rather than integration may explain the increase in false alarms in light-present trials. However, it remains unclear what processes drive illusory touch in light-absent trials. Illusory touch reports in both light-absent and light-present trials are highly correlated with one another (McKenzie et al., 2010), involve similar brain regions (Lloyd, McKenzie, Brown, & Poliakoff, 2011) and are both affected by prior training with bimodal stimuli (McKenzie et al., 2012). This suggests that similar processes are responsible for both types of distortion. Moreover, individual illusory touch rates and response criteria have been found to correlate between testing sessions (spaced 1 week and 4 weeks after the first), whereas individual hit rates and tactile sensitivity have not been found to be correlated between sessions (McKenzie et al., 2010). This indicates a stable trait-like component for illusory touch reports, which is influenced more by decision making processes (response bias) than perceptual sensitivity.

2.9.1. *The SSDT, symptom reporting and health anxiety*

In line with the Brown model, subsequent studies employing the SSDT have found that symptom reporting and health anxiety are associated with illusory touch (i.e. somatic distortion). Brown, Brunt, Poliakoff and Lloyd (2010) employed the SSDT with non-clinical high and low SDQ-20 scorers. In line with Lloyd et al.'s findings, Brown et al. found that presentation of the light significantly increased hit rate, illusory touch rate, tactile sensitivity and the tendency to say yes. However, high SDQ-20 scorers had a greater tendency to say yes irrespective of the presentation of the light and made significantly more illusory touch reports overall. This suggests a general tendency for illusory experiences in ambiguous sensory conditions rather than particular susceptibility to cross-modal perceptual influences. This effect was independent of NA, somatosensory amplification and depression. This suggests that the high SDQ-20 scorers' tendency to experience illusory touch was related to the experience of non-clinical pseudoneurological symptoms rather than to the somatic expression of distress.

Biopsychosocial models suggest that the tendency to experience MUS is associated with a tendency to identify normal sensory fluctuations in somatic awareness as signals rather than noise. This would be supported by a tendency to say yes on the SSDT. Mistaking internal sensations such as finger pulse (noise) for the tactile stimulus (signal) could account for the elevated illusory touch rates. However, following this hypothesis biopsychosocial models would also predict a greater hit rate for high SDQ-20 scorers which was not found in the Brown et al. (2010) study. The comparable hit rates between high and low SDQ-20 scorers indicates that the increase in response bias for the high SDQ-20 scorers was attributable to the increased illusory touch rates, rather than a general tendency to respond yes across all trial types. The overall ability to distinguish signals from noise was therefore comparable between high and low SDQ-20 scorers. This seems inconsistent with the hypothesis that MUS are characterised by a deficit in filtering out irrelevant somatosensory signals.

Further SSDT studies (Brown et al., 2012; Katzer, Oberfield, Hiller, & Witthöft, 2011) have been conducted in student samples. Importantly, both studies found significant positive associations between illusory touch, and more general forms of symptom reporting (as measured by the PHQ-15). Furthermore, Katzer et al. found illusory touch was also positively associated with health anxiety. These associations remained after controlling for relevant covariates (e.g. depression, anxiety and trait anxiety). However, these studies have

found the effect of the light to be inconsistent for illusory touch with both significant and non-significant effects reported. However, both found significant effects for hit rates and response bias, and non-significant effects for perceptual sensitivity.

Katzer et al. also asked participants to rate how often they had perceived their finger pulse in the finger used to detect tactile stimuli during the task. They rated this on a three point scale ranging from 0 ('never') to 2 ('all the time') and found that finger pulse detection was significantly associated with symptom reporting. On first reflection this seems to suggest that people who report more symptoms may be subject to greater amounts of interoceptive noise. This would suggest that there may indeed be a problem with filtering. However, such somatosensory sensations could also be top-down generated in the manner suggested by Brown.

Further SSDT research with clinical samples has also found significant linear associations between symptom reporting and illusory touch. Brown et al. (2012) conducted a study with secondary care patients recruited from an endoscopy clinic, classified as having either medically explained or unexplained bowel complaints. The authors found that the presentation of the light significantly increased hit rates, the tendency to say yes and tactile sensitivity; illusory touch reports were not significantly increased. Both light-absent and present illusory touch were associated with symptom reporting across the entire sample. Furthermore, illusory touch in the light-absent condition was a significant predictor of symptom reporting even when controlling for somatosensory amplification, trait anxiety, health anxiety, anxiety and depression. Although illusory touch was associated with symptom reporting, there were no significant differences in illusory touch rates between the medically explained and unexplained groups. It appears that the number and severity of symptoms more generally, is related to the tendency to experience somatosensory distortion, rather than diagnostic status. However, the patients were grouped upon the diagnostic status of bowel symptoms and only two of the PHQ-15 symptoms relate to bowel symptoms. The diagnostic status of the other thirteen symptoms on the PHQ-15 was unknown. Therefore, it is difficult to know whether MUS, like symptom reporting more generally, are related to somatosensory distortion.

Katzer, Oberfield, Hiller, Gerlach and Witthöft (2012) conducted an SSDT study comparing performance between patients with somatoform disorders (SFD) and healthy controls. They found that, across both groups, presentation of the light had a significant effect on hit rate, response bias and tactile sensitivity, but not upon illusory touch. They found that the SFD group had a more liberal criterion compared to controls in light-absent

trials, even after controlling for covariates (depression, trait anxiety, anxiety and health anxiety). This effect had, however, disappeared by the second block. They also found that, across both groups, illusory touch occurred more frequently in the first block than in the second. In the second half, SFD patients appeared to adopt a response style similar to that of the control group. The authors interpreted this as suggesting that the behaviour in the first test half was more spontaneous and that it was normalised in the second-half suggesting that either task practice and/or fatigue may have played a role. However, this finding is in contrast to previous SSDT studies which have not found significant differences in performance between blocks.

The authors also found that, for the SFD group only, pseudo-neurological symptoms (but not general symptoms) were associated with illusory touch in the first block and illusory touch and response bias in the second block. This association provides further evidence for the link between somatosensory distortion and symptom reporting. It is not clear, however, why there was not a relationship between more general symptom reporting and illusory touch, as has been previously found in the other SSDT studies described above.

Using a more objective threshold procedure (see Chapter 3), Katzer et al. were able to quantify the individual threshold stimulus intensity derived during the threshold procedure. They found that the SFD group had significantly lower detection thresholds for the tactile stimulus than controls, even when controlling for covariates, suggesting that the relationship between threshold and SFD was not due to psychological factors. Indeed, anxiety and depression were associated with *higher* thresholds suggesting they may have opposite effects to somatisation on perceptual threshold. However, symptom reporting within the SFD group was positively associated with detection threshold. This provides mixed support for biopsychosocial models which would predict lower detection thresholds for high symptom reporters. The positive association within the SFD group, however, is in the direction opposite to that expected by biopsychosocial models. This finding may suggest that symptom reporting is associated with attending away from the body. Thus the relationship between tactile threshold and symptom reporting warrants further investigation.

The results of these studies suggest that the tendency to experience distortions in somatic awareness is associated with symptom reporting, even when taking into account psychological factors known to be associated with symptom reporting. As such the relationship between distortions and symptom reporting seems to relate to functional

somatisation rather than the somatic presentation of psychological distress or hypochondriachal concerns.

In line with the Brown model, the preferred interpretation of the results is that a tendency to experience illusory touch on the SSDT may indicate a generally lower activation threshold for somatosensory representations in memory (i.e. easier to elicit 'stimulus present responses') which may be due to a reliance on top-down information rather than bottom-up information when assessing the presence of an ambiguous sensation. However, illusory touch may also reflect a deficit in the ability to filter out sensory noise which is also considered to be a causative factor in the reporting of symptoms. Brown et al. have suggested that these ideas may not be mutually exclusive. A filtering deficit may exist and may affect the reliability of somatosensory information as a source of information about bodily events. This may entail a greater reliance on top-down factors when generating somatic awareness, potentially leading to the activation of 'rogue representations'.

The SSDT studies discussed have demonstrated a robust relationship between the tendency to experience distortions in somatic awareness and physical symptoms (neurological and sensory). The underlying processes that drive illusory touch are, however, less clear. Illusory touch reports are unlikely to represent guesses as the presence of the tactile stimulus is typically rated "definitely yes" in over 20% of illusory touch responses, despite the option of responding with "maybe yes" (McKenzie et al., 2010).

Whilst the presentation of the light consistently increases both hit rates and the tendency to say yes, the light has had less consistent effects on illusory touch and tactile sensitivity. The light was originally included in the task to increase illusory touch rates as earlier research had demonstrated this effect (Johnson et al., 2006). It has been suggested that the sometimes-observed increases in illusory touch in the presence of the light may reflect learning over the course of the task. However, both illusory touch and response bias have generally remained stable over the two test halves; if such learning took place, response bias would be expected to increase over the two test halves. Indeed, in the one study (Katzer et al., 2012) that did find a significant difference between the first and second half, illusory touch decreased on the second half which is counter to the idea that illusory touch reflects learning. A study by Mckenzie, Lloyd et al., (2011) employed a variation of the SSDT in which one block of unimodal and stimulus-absent trials (light only/touch only/no stimulus), was followed by two blocks of bimodal trials (light only/touch only/light & touch/stimulus-absent) and then a final block of unimodal and

stimulus-absent trials. The authors found that this design did not affect the overall pattern of illusory touch. This suggests that prior experience of light and touch pairings are unnecessary for light-induced illusory touch to occur, and that such exposure does not increase the number of subsequent illusory touch reports (e.g. no differences on block four). Thus, visually induced illusory touch is likely to be attributable to an automatic association between light and touch, reflecting typical correlations between multisensory events in everyday experience (Johnson et al., 2006; McKenzie et al., 2011).

Illusory touch could also represent the misinterpretation of internal sensations (such as finger pulse) as the tactile stimulus. This interpretation would fit with biopsychosocial models which propose that high symptom reporters and those who are highly health anxious are subject to a greater volume of sensory noise in somatic awareness. Greater sensory noise may make discriminating ambiguous signals from noise more difficult and hence the opportunity to erroneously report feeling a signal would be increased. The Katzer et al. (2012) finding that SFD patients had lower threshold levels than controls provides some support for the biopsychosocial model. However, it was also found that within the SFD group there was a positive correlation between threshold and symptom reporting which provides conflicting evidence. Indeed, the evidence regarding the perceptual capabilities of those with MUS has been mixed. In heartbeat perception studies, normal perceptual abilities (Barsky et al., 1995; Aronson et al., 2001), enhancement (Scholtz, Ott, & Sarnoch, 2001) and deficits (Mailloux & Brener, 2002) have all been observed. Further investigation of detection thresholds using the SSDT and their relationship to symptom reporting and health anxiety is certainly warranted.

The SSDT studies discussed above have focused on student, secondary care and psychiatric samples. As yet, no SSDT studies have been conducted with primary care patients. Since the majority of MUS are identified and treated in primary care it would seem appropriate to conduct further research within this patient group. All the SSDT studies thus far have been cross-sectional in design; therefore it is entirely possible that the tendency to experience illusory touch is a consequence rather than a cause of symptom reporting. Prospective studies are needed to test this hypothesis.

2.10. The relationship between attention and somatic awareness

Attention and somatic awareness are closely related constructs. However, the theories discussed above propose slightly different relationships between attention and

somatic awareness in the development of MUS and hypochondriasis. Biopsychosocial models generally propose that a body-focused bias changes the contents of somatic awareness by increasing the amount of sensory information in somatic awareness. More specifically, Rief and Barsky (2005) propose deficits in a hypothesised filtering process, which suggests that high symptom reporters may also have lower thresholds for detecting somatosensory stimuli in somatic awareness. Not only then is somatic awareness changed, such that more sensory signals are perceived (more noise), but the filter is decreased such that sensory signals that would not previously have been strong enough to be detected are brought into somatic awareness (increased sensitivity). This would suggest that body-focussed attention and tactile thresholds may be associated with one another; the more body-focused one is, the lower their detection threshold should be. Applying this to the SSDT paradigm, those reporting more physical symptoms should have lower detection thresholds for the tactile stimulus. Similarly, if illusory touch is due to increased sensory noise brought about by attention to the body, then illusory touch reports may also be related to body-focused attention.

According to the Brown model, however, the tendency to make illusory touch reports is an individual difference measure of the tendency to experience somatic distortion when making decisions about the contents of somatic awareness. By this view, illusory touch represents the top-down activation of touch representations in memory which are experienced as current percepts. This is a process considered analogous to the creation of MUS according to the Brown model. The Brown model considers symptom-focused attention to be crucial to the development of MUS. However, in this model, the tendency to experience distortions and symptom-focused attention are separate but related processes. Thus, high symptom reporters would be expected to have both increased levels of symptom focused attention and somatic distortion, whilst low symptom reporters may display increased levels of one but not the other. The two processes may, however, interact to create MUS.

2.11. Research aims and hypotheses

The research presented in this thesis primarily aimed to investigate the relationship between attention, somatic awareness, symptom reporting and health anxiety. The majority of the research was conducted in a prospective study with patients recruited from primary care.

Models of symptom perception, health anxiety and MUS propose that attention to the body is a causative factor in the development of physical symptoms. Biopsychosocial models generally propose a body-focused attentional bias and specific biases for illness-related information (Pennebaker, 1982; Barsky, & Wyshak, 1990; Cioffi, 1991; Rief & Barsky, 2005). Later cognitive-attentional (Brown, 2004) and neurobiological models (Edwards et al., 2012) have implicated attentional biases specifically for symptom representations or abnormal illness beliefs.

The MBT has been used to estimate the degree to which participants are body-focused (i.e. tactile bias), following neutral and threatening body-relevant and body-irrelevant material. According to biopsychosocial models both symptom reporting and health anxiety should be associated with a general tactile bias in all conditions on the MBT. In contrast, cognitive-attentional (Brown, 2004) and neurobiological models (Edwards et al., 2012) would predict that symptom reporting and health anxiety are associated with tactile bias in the threatening body-relevant condition only. There is evidence to suggest that high symptom reporting in student samples may be associated with a body-focused bias under conditions of body-relevant threat. It has also been found that both avoidance of and delayed disengagement from the tactile modality may be important in high symptom reporting in student samples. At present there have been no paradigms directly assessing the relationship between tactile attention and health anxiety. The first aim of this thesis was therefore to test the hypothesis that individual differences in attention to the body are associated with symptom reporting and health anxiety.

Rief and Barsky's (2005) model of MUS, hypothesises that attention to the body, as well as other factors, decreases a pre-conscious filtering mechanism (general bias affecting selection), which in turn increases the volume of sensory information available in somatic awareness. Rief and Barsky propose that somatosensory amplification (specific bias affecting selective attention) explains the interpretation of inert sensations as symptoms indicative of illness. Similarly, Cioffi's (1991) model proposes that self-focused attention makes more information available (general bias affecting selection), but emphasises that a specific bias affecting selective attention determines the relevance of the somatic information, which further influences the perception of physical symptoms. The models of both Rief and Barsky (2005) and Cioffi (1991) would therefor predict that high symptom reporters and those who are highly health anxious have lower thresholds for detecting somatosensory stimuli.

The models of Cioffi (1991), Brown (2004), Rief and Barsky (2005), Barsky and Wyshak (1990) and Warwick and Salkovkis (1990), all propose that specific biases in selective attention influence the contents, or interpretation of the contents, of somatic awareness. Brown's (2004) model, for example, proposes that attention to symptoms decreases the activation threshold of rogue symptom representations stored in the cognitive system. These models would all therefore predict that a tendency to experience distortions in somatic awareness (i.e., false alarms on the SSDT) would be associated with both symptom reporting and health anxiety.

The SSDT provides an opportunity to investigate both individual differences in tactile threshold and the tendency to experience distortions in somatic awareness. Therefore the second aim of this thesis was to test the hypothesis that individual differences in tactile threshold (i.e. lower somatosensory detection thresholds) are associated with both symptom reporting and health anxiety. The third aim of this thesis was to test the hypothesis that somatic distortion is associated with symptom reporting and health anxiety.

The Brown (2004) model suggests that negative affect may directly influence the encoding, storage and selection of rogue symptom representations. The Brown model also hypothesises that both symptom focused attention and the tendency to experience distortions in somatic awareness may interact with negative affect to produce physical symptoms. The fourth aim of this thesis was to test the hypothesis that attention to the body and somatic distortion predict the development of physical symptoms following a negative event.

Finally, little is known about the relationship between attention and somatic awareness. Biopsychosocial models generally suggest that attention to the body lowers the threshold at which somatosensory signals enter somatic awareness therefore it might be expected that individual differences in tactile threshold and the tendency to experience distortions in somatic awareness may be associated with attention to the body. Therefore the fifth aim was to perform an exploratory analysis of the relationship between attention and somatic awareness.

2.12. Participant groups and questionnaires

This thesis details research conducted with student samples (Chapters 3 and 7) and a primary care sample (Chapters 4, 5 and 6). Sample size was not calculated for the pilot

study reported in Chapter 3, as this study was primarily concerned with methodological development. Sample size in the primary care study, and the final student study were calculated using standard formula according to Tabachnick and Fidell (1996; $N \geq 50 + (8 \times$ *No. of predictors)* = sample size) to test the regression and ($N \geq 104 +$ No. of predictors = sample size) to test individual predictors.

Samples specifically identified as having MUS were not investigated. There has been a move away from using MUS as a way of identifying persons of interest (see Chapter 1, Sect. 1.3). Instead, questionnaire measures have been used to assess physical symptom reporting as a continuous construct for the purposes of assessing relationships with other relevant factors. There are a number of different physical symptom measures which have been employed in this area. A recent review found that the 15-item patient health questionnaire (PHQ-15; Kroenke, Spitzer & Williams, 2002) was the most reliable measure of physical symptom reporting for research in this area (Zijlema et al., 2013). Thus, the PHQ-15 was employed as a measure of physical symptom reporting throughout the studies presented here. Each of the PHQ-15 items describes a symptom (e.g. stomach pain, headaches, etc.). Respondents rate the degree to which each symptom has bothered them in the past four weeks using a three-point Likert scale: '0' (not bothered at all), '1' (bothered a little), '2' (bothered a lot). Good reliability and validity of the PHQ-15 have previously been demonstrated Cronbach's α=.80 (Kroenke et al., 2002). As with all general symptom measures the PHQ-15 is likely to be affected by the experience of hypochondriasis ('hypochondriachal somatisation'), NA, anxiety, depression ('presenting somatisation') and organic illness.

The short-form health anxiety inventory (HAI-short; Salkovkis, Rimes, Warwick, & Clarke, 2002) was employed to measure health anxiety as an outcome variable and to control for the effects of hypochondriachal somatisation. The HAI consists of 18 items, each comprising four statements pertaining to an aspect of health anxiety. Respondents indicate which of each set of statements best describes their feelings in the preceding 6 months. Each statement carries a score from 0 to 3, with increasing scores corresponding to higher levels of health anxiety. The scale reliability in the original validation report was Cronbach's α=0.89 (Salkovkis et al., 2002).

In addition to measuring symptom reporting and health anxiety as outcome measures, in the primary care study we also measured health care utilisation. Health care utilisation is considered a maintaining factor in cognitive models of MUS and health anxiety (e.g., Deary et al., 2007; Brown, 2004; Warwick & Salkovkis, 1990). Increased

symptom reporting has also been found to be an independent predictor of increased health care utilisation, irrespective of organic disease, mental illness and socioeconomic factors (Ladwig et al., 2010; Barsky et al., 2005). Thus, although these factors account for a large and important part of the variation in symptom reporting (Crombez, Beirens, Van Damme, Eccleston, & Fontaine, 2009), there is also a significant amount of variance unaccounted for that exerts an independent effect on health care utilisation (Ladwig et al., 2010). Thus we wished to investigate whether attentional and perceptual process exert independent or mediated effects (i.e., via symptom reporting and health anxiety) on health care utilisation.

In order to investigate the relationship between attention somatic awareness, symptom reporting and health anxiety we also measured and controlled for the effects of gender, age, NA and psychopathology throughout. Furthermore, in the primary care study the presence of chronic medical conditions was also controlled for. Details of the additional measures used in each study are provided in the individual chapters.

Chapter 3. Task development

3.1. Introduction

The study described in this chapter was a pilot study primarily concerned with task development. Methodological changes were made to both the design and analysis of the MBT and to the thresholding procedure of the SSDT. The revised tasks were piloted in a student sample to assess their validity and reliability as measures of attention (as measured by the MBT) and somatic awareness (as measured by the SSDT). In addition, the relationships between attention, somatic awareness, symptom reporting and health anxiety were investigated.

3.1.1. *MBT development*

The original MBT study found that non-clinical high pseudo neurological symptom reporters only displayed a significant tactile bias following threatening body-relevant picture cues at an SOA of 250ms (Brown, Poliakoff, & Kirkman, 2007).This effect was lost when targets were presented after a slightly longer SOA of 500ms. This suggests that high pseudo neurological symptom reporters only direct additional attention to their bodies immediately after exposure to threatening body-relevant information (for a full discussion of this task see Chapter 2, Section 2.6.4). This attentional effect is therefore considered to be relatively automatic or exogenous. Thus, in the present study target performance was assessed following a SOA of 250ms only. However, a small number of trials (known as 'catch trials') with a SOA of 500ms were included so that the onset of the target was not predictable, with a view to minimising anticipatory responses.

The reduction of the MBT to one SOA (original MBT study: 204 trials; 48 pictures) resulted in fewer experimental trials overall (present MBT study: 172 trials; 32 pictures), and so the number of picture cues required in each of the picture conditions (neutral-scene; threat-scene; neutral-body; threat body) was reduced. The picture set was therefore reviewed and some pictures were identified as difficult to discriminate in the short (200ms) presentation period. The selection of the original picture set was based on the subjective threat ratings of independent raters. However, the raters were exposed to the pictures for an unrestricted time period. Therefore the content of some of the pictures appeared too complex for the presentation period. Thus eight new pictures were selected (neutral-scene = 0; threat-scene = 3; neutral-body = 2; threat-body = 3) and 24 pictures were taken from

the original set. This resulted in a total of eight pictures in each picture condition. In order to check that the revised picture set was appropriate, at the end of the MBT, participants were exposed to each picture for 200ms and then asked to rate it on perceived level of threat.

In the original study, the relationship between pseudo neurological symptoms and individual differences in tactile performance relative to visual performance (i.e., tactile bias) was analysed. Because an individual analysis of visual and tactile performance was not performed, it is difficult to determine the exact nature of the tactile bias measure. Quicker performance for tactile targets relative to visual targets may reflect facilitation for the tactile modality, as implied by the term 'tactile bias'. However, it may also reflect delayed disengagement from the picture cues (e.g., slower RT's), which could conceivably have a disproportionate effect on the detection of visual targets, as both cue and target require visual attention. Thus, the measure could be indicative of delayed disengagement, rather than a bias for the tactile modality per se. In order to aid clarity, in the present study, three performance variables were calculated: visual performance, tactile performance and tactile bias. If the tactile bias measure does measure body-focused attention, then we would not expect a significant positive correlation between visual performance and symptom reporting. The present study also extended the original study by investigating whether MBT performance was related to more general forms of symptom reporting (e.g. pain, fatigue, headaches, etc.) and health anxiety.

3.1.2. *SSDT development*

In order that the tactile stimulus delivered in the SSDT is equally ambiguous for all participants, each participant undergoes a thresholding procedure. The thresholding procedure determines the level of tactile stimulation necessary to elicit a correct yes response in 40-60% of light-absent trials. This level of stimulation is referred to as the participant's tactile threshold. The intensity of the stimulation derived in the thresholding procedure determines the strength of the decision signal in subsequent experimental trials. This affects the frequency of hits and may also affect the frequency of illusory touch reports (FAs). Signal detection statistics *d*' (tactile sensitivity) and *c* (response bias) are also based on the frequency of hits and false alarms. Thus determining tactile threshold accurately is integral to the SSDT.

Katzer, Oberfield, Hiller and Witthöft, (2011) identified a serious disadvantage with the thresholding procedure used in earlier SSDT studies. Katzer et al., reasoned that using a single interval (yes/no) trial task, in which a vibration may or may not be presented, means that the participant's response bias affects their performance on the procedure. In order to reduce the effects of response bias, the authors employed a more objective two-interval trial 'forced choice' task. Forced choice tasks are considered to involve minimal amounts of response bias, because indicating which time interval ('one' or 'two') a stimulus occurred in represents a smaller difference in subjective values than responding 'yes' or 'no' to a single interval trial (Green & Swets, 1966). Thus, in a two forced choice task, tactile threshold is arrived at in a more objective way (i.e., based on tactile sensitivity rather than response bias).

Using the more objective procedure Katzer et al., achieved an average hit rate in light-absent trials of 57% (*SD* 20%). This is within the 40-60% hit rate expected for those on threshold in single interval trials and suggests their procedure was effective. In order to assess reliability the authors employed the same procedure at the end of the SSDT. The test-retest correlation indicated their method was highly reliable (r_{tt}= .84). However, the Katzer et al. procedure, like the original threshold method (Lloyd et al., 2008), was delivered manually (the experimenter manually adjusted the stimulus intensity). There is, therefore, greater potential for variability in technique and human error to affect the procedure. In addition, the tactile threshold itself cannot be empirically quantified. In the present study a fully computerised two forced choice task was employed. The selection of the vibration level was made using a computer algorithm known as PEST: Parameter Estimation by Sequential Testing. PEST is an adaptive method which calculates fast and efficient estimates of psychophysical parameters such as tactile threshold (Taylor & Creelman, 1967). Employing a fully computerised method not only eliminates human error and variability in technique but also allows the tactile threshold of each participant to be quantified and recorded. This meant a second measure of somatic awareness could be included in the present study: the level of stimulation necessary for the tactile stimulus to be perceived (i.e., tactile threshold).

3.2. Study aims and research hypotheses

The aims of the study were twofold. The first aim was to assess the reliability and validity of the revised tasks. In particular, we wanted to establish whether (i) the revised

picture set in the MBT provided an effective manipulation (i.e., that body and scene pictures in neutral and threatening conditions are matched on perceived threat level and that neutral pictures are rated as significantly less threatening); (ii) the revised thresholding procedure on the SSDT yielded thresholds within the expected range for at least 80% of participants; (iii) the revised SSDT thresholding procedure yielded thresholds with adequate test-retest reliability; and (iv) participants' performance on the tasks were consistent with previous research (e.g., MBT: that visual target performance is poorer than tactile target performance and performance is significantly poorer in the threatening body-relevant condition; SSDT: that there is a significant effect of the light and non-significant effect of block on performance), which we regarded as an important step in determining task validity.

The second aim was to conduct a preliminary investigation of the relationships between attention, somatic awareness, symptom reporting and health anxiety (see chapter 2, Section 2.11 for a discussion of the hypothesised relationships between these variables). For this aim, we had the following hypotheses: (i) there would be a significant positive correlation between tactile bias on the MBT in the threatening-body-relevant condition, symptom reporting and health anxiety; which (ii) would remain after controlling for age, gender, trait anxiety, anxiety and depression; (iii) there would be a significant negative correlation between tactile threshold on the SSDT, symptom reporting and health anxiety; (iv) there would be a significant positive correlation between false alarm rate on the SSDT, symptom reporting and health anxiety; which (v) would remain after controlling for age, gender, trait anxiety, anxiety and depression.

We also had the following exploratory aims: (i) in order to better understand the relationship between tactile bias and symptom reporting we investigated whether visual and tactile performance were associated with symptom reporting and health anxiety; and (ii) we investigated whether somatic awareness (SSDT: tactile threshold and false alarms) and attention (MBT task performance) were significantly correlated with one another.

3.3. Method

3.3.1. *Participants*

Twenty-seven students and staff (11 female; age range 18.11yrs-48.50yrs; mean age 24.0 [*SD*=7.0yrs]; 25 right-handed according to the EHI, Oldfield, 1971) were

recruited from the University of Manchester. All participants gave written informed consent prior to participation. The study was approved by the University Research Ethics Committee. All participants had normal (or corrected-to-normal) vision, and none reported any tactile sensory deficits. Each participant received a £10 gift voucher or course credits for participation. Participants were naïve to the exact purposes of the study.

3.3.2. *Overall study design and procedure*

A repeated measures design was implemented. Participants attended one single session lasting approximately two hours. To ensure the set-up of the SSDT was appropriate (which required the use of the index finger of the non-dominant hand to detect tactile pulses), handedness was first determined using the Edinburgh Handedness Inventory (EHI; Oldfield, 1968). Participants then completed the SSDT, followed by five self-report questionnaires measuring symptom reporting, health anxiety, state and trait anxiety and depression (see Section 3.3.3 below for details); finally they completed the MBT. Participants completed the SSDT first so that their tactile detection threshold was not affected by receiving the supraliminal vibrations given in the MBT. Participants completed the experimental tasks individually, in a light attenuated room, in front of a stimulus array (PC monitor and task equipment). E-Prime software (Psychology Software Tools Inc., Pittsburgh, PA, USA) was used to present task stimuli and also to record responses. White noise was presented throughout the computer tasks via headphones, so that ambient noise and sounds produced by the vibrations delivered during the tasks could not be heard by participants.

3.3.3. *Questionnaires*

Symptom reporting and health anxiety were measured using the PHQ-15 and short form HAI, full details of which can be found in Chapter 2, Section 2.12. In order to control for the effects of state and trait anxiety (which is often used as a proxy for NA), the state-trait anxiety inventory (STAI-T/S; Speilberger, 1983) was employed. The state component of the inventory asks respondents to rate how they feel ‘right now, that is at this moment’ in response to 20 statements pertaining to anxiety which respondents rate on a scale from 1 (‘not at all’) to 4 (‘very much so’). Responses are scored from 1-4 (some items are reverse scored) and higher scores indicate greater levels of anxiety. The scale reliability in the original validation report was Cronbach’s α=0.90). The trait component of the inventory

asks respondents to indicate how they 'generally feel' in response to 20 items pertaining to anxiety, which the respondent rates on a scale of 1 ('almost never') to 4 ('almost always'). The scale reliability in the original validation report for trait anxiety was Cronbach's α=0.93 (Speilberger, 1983).

In order to control for the effects of depression the PHQ-9 (Kroenke, Spitzer & Williams, 2001) was employed to control for the effects of depression. The PHQ-9 consists of nine common symptoms of depression; respondent indicate the degree to which they have been bothered by each symptom in the last two weeks on a 4-point scale ranging from 0 ('not at all') to 3 ('nearly every day'). Scale reliability in the original validation report was Cronbach's α=0.86-0.89.

3.3.4. *Modality Bias Task*

Participants were seated in front of a computer monitor with their left hand positioned 4.5cm to the left of the centre of the monitor and their right hand in the same position 4.5cm to the right of the centre of the monitor. In each hand, they held a rectangular foam cube (65 x 55 x 25mm), attached to the table (see figure 3.1 below). The pad of the participant's left and right index fingers were placed on bone conductors mounted in each of the foam cubes. The conductors had a vibrating surface 16mm wide and 24mm long (Oticon Ltd., B/C 2-PIN, 100 Ohm, Hamilton, UK) and were used to present suprathreshold vibrotactile targets (200Hz vibration for 300ms). The vibrotactile targets presented to the left and right hands were subjectively matched for strength individually for each participant. Two red LEDs (10mm in diameter) were mounted on a plastic cube (25 x 25 x 25mm) and attached to the bottom of the computer monitor. Each was positioned 4.5cm to the left and 4.5cm to the right of the centre of the monitor respectively (in line with the hand held foam cubes). The LEDs were used to present the visual stimulus (300ms light flash). Two foot pedals were positioned on the floor: one under the participant's left toes and one under their right. Participants responded as quickly and as accurately as possible to the location (left or right) of the target stimulus (light or vibration) by lifting their left or right toes.

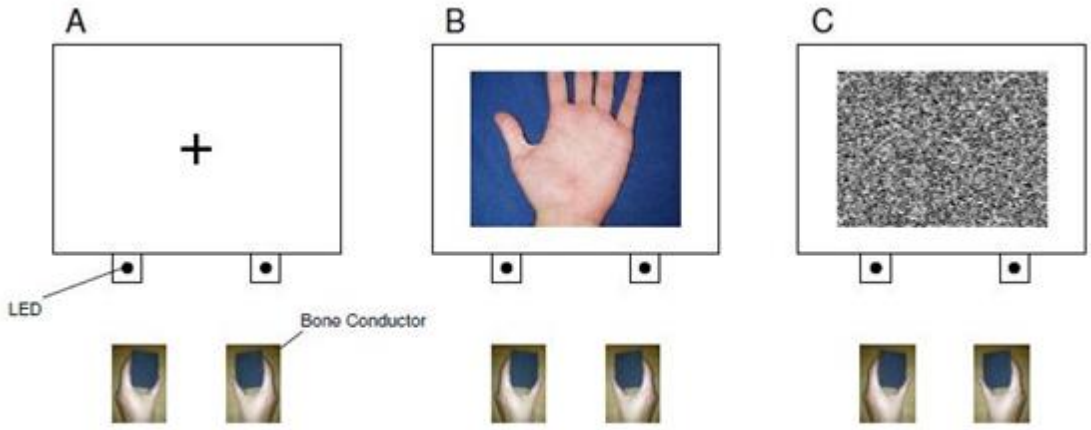

Figure 3.1 Schematic of the Modality Bias Task

The MBT employed a repeated measures design with picture valence (neutral vs. threatening), picture type (body stimuli vs. scene stimuli) and target modality (visual vs. tactile) as the within-subject variables. The picture cues were digital colour photographs (500 x 368 pixels) of four different types: neutral-scene, threat-scene, neutral-body and threat-body. There were eight different pictures in each category and neutral and threatening pictures of each type were matched; for example, a picture of a car (neutral-scene) was matched with that of a car crash (threat-scene). Neutral-body pictures consisted of: four hands (two left, two right), one right arm, one left toes, one leg and one leg and foot. Threat-body pictures consisted of: four injured hands (cut to hand, severed thumb, nail injury, finger wound), one wounded arm, one wounded left toes, one wounded leg, and one wounded foot and ankle. Neutral-scene pictures consisted of: four cars, one train, one lorry, one aeroplane, one house. Threat-scene pictures consisted of: four car crashes, one train crash, one lorry, one aeroplane and one house all on fire. There were no people (or any other living organism) shown in any of the scene pictures.

Participants first completed a practice block of 27 trials (2 each of 12 pictures of neutral household objects [e.g. a spoon]and 3 probe trials), followed by four experimental blocks of 43 trials; each block contained 35 trials with an SOA of 250ms and 5 catch trials (SOA 500ms). Each experimental picture was displayed once per block, except in one block where it was also displayed in a catch trial. Across the experiment, each individual picture was followed twice by the target stimulus on the left and twice on the right, with half of these being a visual target and the other half being tactile.

In each trial, a central fixation cross was presented for 700-1000ms, after which the picture cue was presented for 200ms. This was then replaced by a visual white noise mask which remained on screen for the remainder of the trial. Following the offset of the picture cue, the target was presented either 50 or 250ms later. This produced an SOA of 250ms or 500ms between the onset of the picture cue and the target. The trial ended once the participant made their response. The screen was then blank for 200ms prior to the start of the next trial; if the participant made the wrong response then a message saying 'wrong' in red was displayed during this interval. Participants were also asked to respond verbally to 12 rare probe pictures (neutral scene), which were not part of the main experimental stimuli. Each probe picture had a centrally located fluorescent green digit (font size, 48). Participants were asked to say these numbers out loud and their responses were recorded by the experimenter. Three probe trials appeared in every test block and the reaction times obtained in these trials were not analysed. The probes were included to ensure that the participants were attending to the picture stimuli throughout the experiment; the mean accuracy rate of 96% for these pictures indicates that this was the case.

After the experiment, participants were presented with each of the 32 pictures for 200ms and then asked to rate the level of threat for that picture (on a ten point scale; 0 = not threatening to 9 = the most threatening you can imagine) by entering their rating on the keyboard.

3.3.5. *Somatic Signal Detection Task*

Participants sat with their non-dominant hand resting on a table in front of and central to the computer monitor. The pad of their non-dominant index finger was attached using an adhesive double-sided pad to a bone conductor, mounted on a foam wedge with a vibrating surface 1.6cm wide × 2.4cm long (Oticon Ltd, B/C 2-PIN, 100 Ohm, Hamilton, UK). The bone conductor was used to present the tactile vibrations. Tactile vibrations were produced by amplifying sound files from the computer via a custom built amplifier (Dancer Design). The volume dial on the amplifier was set at the quarter-to-twelve position for each participant. A red LED (5mm) was also mounted on the foam cube close to the end of the participant's finger to provide the visual stimulus (light). The monitor was used to deliver instructions and a visual start cue: a green arrow (962 x722 pixels) that was centrally presented and pointed downwards towards the finger adhered to the bone conductor. Participants responded via the computer keyboard, using their dominant hand.

3.3.6. *Thresholding procedure*

Each participant's tactile threshold was determined using a computerised forced choice adaptive procedure. Participants were presented with a series of trials consisting of two time periods. Each time period was demarcated by the same visual start cue used in the experimental phase of the task. However, during the threshold procedure a number one was overlaid centrally on the arrow for time period one and a number two for time period two. Each trial consisted of a stimulus-present time period and a stimulus-absent time period presented in a random order. In stimulus-present periods, a 20ms tactile vibration (100Hz) was delivered with a delay of 500ms before and afterwards, while in stimulus-absent periods no vibration was presented for 1020ms. A prompt then appeared on the screen and participants were required to press numerical keys ("1" for period one and "2" for period two) to report when they judged the vibration to have occurred. If participants could not feel a vibration in either time period they were instructed to guess which time period the vibration had occurred in.

The selection of the vibration level was made using PEST, which began by delivering a vibration level equal to 274 m/s (as measured by an accelerometer attached to the bone conductor). This vibration level was painless but quite strong and was chosen so that it would be clearly felt by participants. The intensity of the vibration was defined using a scale of arbitrary units that ranged from 0 (maximal stimulation which was equal to the initial vibration level 274 m/s) to a minimum of -10,000. A Wald sequential probability ratio test (SPRT) was used to define when to change the vibration strength [N(c) (no. of correct responses) - Pt.N (T) (probability threshold value (0.75) multiplied by current trials completed) $\geq$ W (W's limits were: 1 to-1)]. The selection of the vibration level depends on the responses given on all trials since it reached its current level. When participants' correct responses were significantly greater than 75%, this caused the Wald SRPT to be greater than W = 1 and a weaker vibration level was selected (step-down). When participants' correct responses were significantly less than 75% this caused the Wald SRPT to be less than W= -1, and a stronger vibration level was selected (a reversal). Initial step size (the difference between vibration levels) was set at 800, minimum step size at 50 and maximum step size at 3200. Step size was determined according to the following rules:

1. The second step in a given direction is the same size as the first.
2. After each reversal, halve the step size unless it follows a double.

3. After each reversal that follows a double, no change to the step size.
4. If the third step in a row is in the same direction then double the step size.
5. The fourth and subsequent steps in a given direction are each double their predecessor.
6. End when the minimum step size is reached.

The computer algorithm was programmed to complete a maximum of 250 trials, and, if this limit was reached, an average of the last 50 trials was taken as the participant's vibration level. The same thresholding procedure was repeated at the end of the experimental trials to assess the reliability of the procedure. The visual stimulus (light) was not presented during either thresholding procedure.

3.3.7. *Experimental phase*

The SSDT employed a repeated measures design with tactile vibration (present vs. absent) and light (present vs. absent) as the within-subject variables. The experimental phase consisted of two 80-trial blocks with a break in between. Each trial consisted of a single interval in which one of the four trial types was presented. Each trial type was presented 20 times per block in a random order. Vibrations were presented at the intensity determined in the thresholding procedure. Each trial was preceded by the same visual start cue (see section 3.3.5) as used in the thresholding procedure. In vibration-present trials a 20ms tactile stimulus (100Hz) was delivered with a delay of 500ms before and afterwards. In vibration absent trials an empty 1020ms period occurred. In light-present trials, a 20ms visual stimulus (LED flash) was also presented in the middle of the 1020ms stimulus period, either on its own (vibration absent) or at the same time as the tactile pulse (vibration present). Participants indicated whether they had felt the tactile vibration using numerical keys: 1 = "definitely yes", 2 = "maybe yes", 3 = "maybe no" and 4 = "definitely no". Participants completed 10 practice trials prior to completing the two 80-trial blocks to familiarise them with the new response protocol and the light stimulus. Participants were naive to the significance of the visual stimulus and were informed that a vibration would not be present on all trials. No other instructions were given.

3.4. Statistical analysis

3.4.1. *Data preparation*

Prior to analysis, the data from both the MBT and SSDT were prepared according to the following procedure.

MBT data. Trials on which an error was made were excluded from the analysis (3.6%). These included anticipatory responses (<150 ms) and incorrect left/right responses; there was no upper limit for response times. The remaining RTs for each participant in each condition were then subjected to an outlier removal procedure (van Selst & Jolicoeur, 1994), and mean RTs were calculated for each participant in each sub-condition (for visual and tactile targets separately). The mean RTs were then combined with error rates (or proportion of wrong errors) to calculate inverse efficiency for each participant in each sub-condition [RT/ (1-proportion wrong error)]. This measure combines speed and accuracy and allows comparisons between conditions without contamination by potential speed-accuracy trade-offs (Townsend & Ashby, 1983). A tactile bias score was then calculated for each picture condition (IE visual-IE tactile). Positive scores indicate that the inverse efficiency was higher (i.e., responses were slower and/or less accurate) for the visual modality than for the tactile modality (i.e., there was a bias towards touch).

SSDT data. Participant responses on the SSDT were categorised into "yes" or "no" responses because not all participants had used all four response categories. Responses on each trial were classified as hits, misses, false alarms and correction rejections. Data from each block were analysed separately and hit rate, false alarm rate, tactile sensitivity (*d'*) and response bias (*c*) were calculated using the log linear correction (Snodgrass & Corwin, 1988) (hit rate = [{number of hits + 0.5}]/{number of hits + number of misses + 1}] and false alarm rate = [{number of false alarms + 0.5}/{number of false alarms + number of correct rejections + 1}]). These were then used to calculate the signal detection theory test statistics *d*' (*Z* [hit rate] – *Z* [false alarm rate]), which estimates the participants perceptual sensitivity, and *c* (-0.5[*Z* {hit rate} + *Z* {false alarm rate}]), which estimates the participants response criterion (i.e. tendency to say yes (i.e. to report the signal as present).

3.4.2. *Data distribution*

Both questionnaire and task data were screened for normality. Non-normal variables (see Appendix B, Section B.1 for full details) were transformed using log and

square root transformations as appropriate, following the recommendations of Tabachnick and Fiddell (1996). Tactile bias in the threat-body condition was non-normal and could not be transformed; the transformation of one single outlying participant (with a score > 2SD from the mean) to the next highest score plus 1SD normalised the data. The following variables were non-normal and were unable to be transformed: tactile threshold pre- and post-experimental trials; Block 1 and Block 2 light-absent hits, false alarms and block 2 light-present hits. Therefore non-parametric tests were used in the analysis of these variables.

3.4.3. *Analyses addressing study aims and hypotheses*

MBT. To establish the validity and reliability of the MBT the following analyses were conducted. A manipulation check was performed on participant's subjective threat ratings of the pictures, using Wilcoxon matched-pairs tests. Repeated measures ANOVAs and t-tests were used to analyse the effect of the picture cues on MBT performance (visual, tactile and tactile bias). In order to address the study hypotheses, correlations were conducted between MBT performance and sample characteristics. Hierarchical multiple regressions, controlling for relevant covariates, were conducted to evaluate whether MBT performance was independently associated with symptom reporting and health anxiety. Total PHQ-15 and HAI score were the target variables; MBT performance was analysed for each picture condition separately.

SSDT. To establish the validity and reliability of the new threshold procedure the following analyses were performed. Block 1 light-absent hit rates were screened to establish whether participant performance was in the 40-60% range expected. Test-retest correlations were conducted between the pre- and post-experimental threshold measurements. Tests of difference were conducted between block 1 and 2 and between light-absent and light-present trials. In order to address the study hypotheses, correlations were conducted between tactile thresholds, false alarms, symptom reporting and health anxiety. Hierarchical multiple regressions were conducted to evaluate whether false alarms were independently associated with symptom reporting and health anxiety. Total PHQ-15 and HAI score were the target variables; false alarm rate was analysed in each block and light condition separately.

SSDT & MBT. In order to investigate the exploratory study aim correlations were conducted between somatic awareness (false alarm rate and tactile threshold on the SSDT) and attention (visual and tactile performance on the MBT).

Overall. Two-tailed tests of significance are reported throughout, an alpha level of .05 was used, and measures of effect size are all Pearson's *r*, or for non-parametric correlations Spearman's *r; r*≥.10 was considered a small, *r*≥.30 a medium, and *r*≥.50 a large effect. All statistical analyses were conducted using SPSS version 20.0 (IBM SPSS Inc., Chicago, IL).

3.5. Results

3.5.1. *Questionnaire data*

Descriptive statistics for the untransformed questionnaire data are presented in Table 3.1 below. Physical symptom reporting (PHQ-15), health anxiety (HAI), trait anxiety (STAI-T), state anxiety (STAI-S) and depression (PHQ-9) rates were low in this sample. PHQ-15 scores > 10 (Körber et al., 2011) and HAI scores > 18 (Salkovskis et al., 2002) indicate clinically relevant levels; none of the participants in this sample fell in this range for symptom reporting and seven participants fell in this range for health anxiety. Cronbach's alpha indicated good reliability for the measures of health anxiety, trait and state anxiety, and depression, however, the reliability of the symptom reporting measure was poor for this sample.

Table 3.1 Descriptive statistics for the questionnaire data (n = 27)

Questionnaires	Median (IQR)	Mean (S.D)	Cronbach's *α*	Actual range	Possible range
PHQ-15	5 (3.00)	5.52 (2.68)	0.46	0-10	0-30
HAI	14 (8.00)	14.22 (5.55)	0.80	4-27	0-54
STAI-T	40 (10.00)	40.85 (8.85)	0.90	27-60	20-80
STAI-S	35 (12.00)	35.56 (9.64)	0.92	21-57	20-80
PHQ-9	3 (3.00)	3.56 (3.51)	0.79	0-18	0-21

Table 3.2 below presents zero-order correlations between demographics and questionnaire measures. Health anxiety, trait anxiety, state anxiety and depression were all

significantly correlated with one another. Age, gender and symptom reporting were not significantly correlated with each other or any of the other measures. However, the correlations between symptom reporting and age, health anxiety, trait anxiety and depression were all > r = .30, which represents a medium effect. The sample size recruited in this study was small (n = 27). A sample size calculation indicated that 84 participants would be required to achieve 80% power to detect a correlation of this magnitude using a two-tailed test with a significance level of .05. This suggests that the study was under-powered, increasing the probability of Type II errors.

Table 3.2 *Zero-order correlations between demographics, symptom reporting and psychopathology (n = 27).*

	Age	Gender	PHQ-15	HAI	STAI-T	STAI-S	PHQ-9
Age	-	-.01	.33	.13	.26	.24	-.04
Gender		-	.26	.01	.04	.20	-.16
PHQ-15			-	.35	.31	.23	.32
HAI				-	.51**	.54**	.45**
STAI-T					-	.70**	.63**
STAI-S						-	.41*

*p<.05. ** p <.001.

3.5.2. *MBT*

Does the revised picture set provide an effective manipulation?

The median threat ratings for the picture conditions were: neutral-scene, .00; neutral-body, .00; threat-scene, 5.75; threat-body, 6.25. Threat-scene pictures were rated as significantly more threatening than neutral-scene pictures (z = -4.54, p < .001, r = -.87) and threat-body pictures were rated as significantly more threatening than neutral-body pictures (z = -4.54, p < .001, r = -.87). Threat-body and threat-scene pictures (z = -.69, p =.50) and neutral-body and neutral-scene pictures (z = 1.30, p = .20) were matched on perceived threat level. The threat ratings indicate that the manipulation was appropriate.

Is visual target performance poorer than tactile target performance and is performance in the threatening body-relevant condition significantly poorer?

Mean visual and tactile performance (IE; Figure 3.2) in threatening and neutral body-relevant and irrelevant picture conditions is displayed in figure 3.1 below.

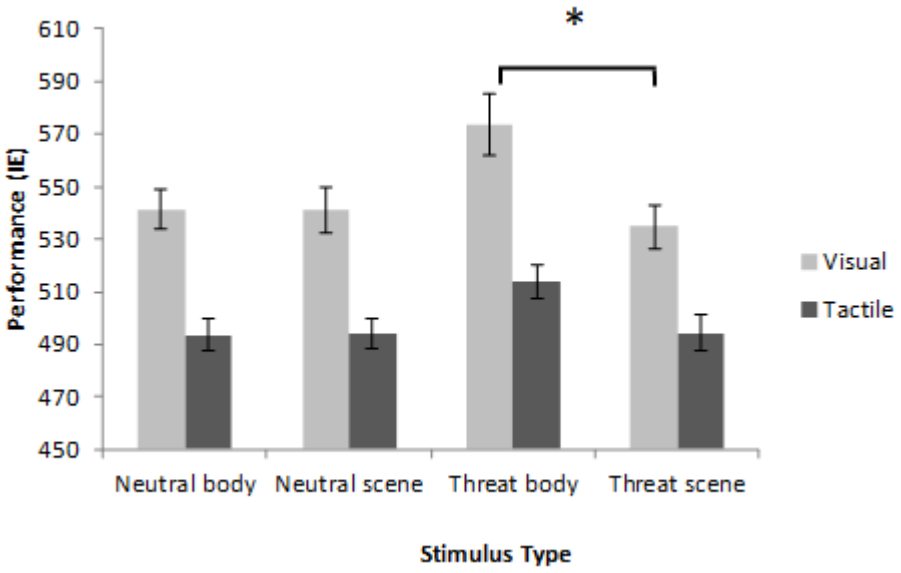

*Figure 3.2 Adjusted mean (SE) visual and tactile performance (IE) for each picture condition (Note: * $p < .05$).*

The MBT performance data was analysed with a 2 (picture-valence: neutral vs. threatening) x 2 (picture-type: body vs. scene) x 2 (target-type: tactile vs. visual) within-participants repeated measures analysis of variance (ANOVA). There was a near-significant main effect of picture-valence (F, (1, 26) = 3.58, p = .07) with poorer performance following threatening pictures than neutral pictures (neutral mean = 517.42; threatening mean = 529.08). There was a significant effect of picture-type (F, (1, 26) = 5.65, p = .03) with poorer performance following body-relevant pictures than body-irrelevant pictures (body mean = 530.51; scene mean = 515.99). There was a highly significant effect of target-type (F, (1, 26) = 17.82, $p < .001$) with poorer performance for visual targets than tactile targets (visual mean = 547.49; tactile mean = 499.01). There was a significant interaction between picture-valence and picture-type (F, (1, 26) = 11.64, p = .03), but not between picture-valence and target-type (F, (1, 26) =.32, $p > .05$), or between picture-type and target-type (F, (1, 26) = .84, $p > .05$). The three-way interaction between

picture-type, picture-valence and target-type was also non-significant (F, (1, 26) = .46, p > .05).

As there was a significant interaction between picture-valence and picture-type, a series of follow-up t-tests were conducted. Visual performance in the threat-body condition was significantly poorer than performance in the threat-scene condition (t = 2.47, 26, p = .02). There was also a trend for both tactile and visual performance in the threat-body condition to be poorer than performance in the neutral-body condition (tactile: t = -1.94, 26, p = .06; visual: t = -1.83, 26, p = .08). There were no other significant differences between conditions (all p's > .10). These results suggest that poorer performance in the threat-body condition was the main source of the significant interaction between picture-type and picture-valence.

The results of the ANOVA revealed that performance for visual targets was significantly poorer than performance for tactile targets; consequently there was a substantial tactile bias for all picture conditions. Visual performance in the threat-body condition was significantly poorer than visual performance in the threat-scene condition, and there was a trend for tactile performance to be poorest in the threat-body condition. These findings are consistent with prior expectations regarding visual and tactile performance (see discussion Section 3.6.1). They are also consistent with the findings of the original MBT study, which also found a significant tactile bias for all picture conditions.

A two way analysis of variance (ANOVA) was performed on the tactile bias data, with picture-type and picture-valence as within-subject variables. The main effects of picture-type (F, (1, 26) = 1.81, p > .05) and picture-valence (F, (1, 26) =1.97, p > .05) and the picture-type × picture-valence interaction (F, (1, 26) =1.70, p > .05) were all non-significant. Similarly, in the original study there was only a significant three way interaction between picture-valence, picture-type and group (high vs. low pseudo neurological symptom reporters) for tactile bias, with tactile bias being greatest in the threat-body condition.

Are there significant positive correlations between tactile bias in the threatening-body relevant condition, symptom reporting and health anxiety?

There were large correlations between tactile bias in neutral-body and neutral-scene conditions and symptom reporting that were statistically significant. These results suggest

an apparent association between the tendency to focus on the body, and symptom reporting in line with the original MBT study findings. The association between tactile bias in the threat-body condition and symptom reporting yielded a medium sized effect, however, this was not statistically significant. The positive association between tactile bias in the threat-scene condition and symptom reporting and the associations between tactile bias in the neutral-scene, neutral-body, and threat-body conditions and health anxiety all yielded small sized effects. There was a medium positive association between tactile bias in the threat-scene condition and health anxiety.

In order to investigate the nature of the relationship between tactile bias, symptom reporting and health anxiety further correlational analyses was conducted between symptom reporting, health anxiety and tactile and visual performance on the MBT separately.

What is the relationship between MBT performance, symptom reporting and health anxiety?

Zero-order correlations were conducted between tactile and visual performance, symptom reporting and health anxiety (see Table 3.3, below). Contrary to the hypothesis, there were positive correlations between visual performance in all conditions and symptom reporting, which yielded medium to large sized effects. In addition, positive correlations between tactile performance and symptom reporting, although non-significant, also yielded medium sized effects. In contrast, there were negative correlations between tactile and visual performance and health anxiety, which yielded small to medium sized effects. These results suggest that, in general, poorer performance on the MBT is associated with increased symptom reporting. Interestingly, better tactile performance may be associated with health anxiety.

A number of correlations have been conducted in this analysis, which inflates the chance of making a type I error. However, the small sample size means there is also a lack of power to detect significant effects thus increasing the likelihood of making type II errors. Thus the effect sizes and overall pattern of results have been used in the interpretation of these results rather than their level of significance.

Table 3.3 Zero-order correlations (Pearson's and Spearman's) between and MBT performance in the four stimulus conditions, symptom reporting and health anxiety (n = 27).

	PHQ-15	**HAI**
Tactile bias		
Neutral-body	.46*	.08
Neutral-scene	.48*	.09
Threat-body	.34	.11
Threat-scene	.11	.30
Tactile Targets		
Neutral-body	.27	-.25
Neutral-scene	.25	-.29
Threat-body	.18	-.24
Threat-scene	.32	-.27
Visual targets		
Neutral-body	.43*	-.13
Neutral-scene	.49**	-.17
Threat-body	.40*	-.13
Threat-scene	.36	-.06

*p<.05. ** p <.001.

Do the relationships between MBT performance, symptom reporting and health anxiety remain when controlling for age, gender, trait anxiety, anxiety and depression?

The individual analysis of visual and tactile performance suggests that symptom reporting is associated with poorer performance on the task in general and with visual performance in particular, rather than facilitation for the tactile modality. Therefore, the association between tactile bias and symptom reporting seems to be attributable to the

relationship between visual performance and symptom reporting. For this reason further multivariate analyses were conducted on visual and tactile performance separately and were not conducted on the tactile bias data.

It is possible that the association between poorer MBT performance and symptom reporting is mediated by age or other factors, rather than, attentional effects related purely to the picture cues. In order to control for the effects of age on task performance in subsequent multivariate analyses, performance in the neutral-scene condition was included as a covariate. The neutral-scene condition may be considered the condition that most closely relates to a neutral condition on the task. It is likely that performance in this condition most closely reflects participants' general performance on the task. Controlling for general task performance should allow any relationships between disengagement and target variables to be identified[1].

To estimate the relationship between MBT performance, the tendency to experience physical symptoms and health anxiety, other potentially confounding variables were also controlled for: age, gender, trait anxiety, anxiety and depression. Health anxiety was also controlled for in analyses focusing on symptom reporting, whereas symptom reporting was controlled for when focusing on health anxiety.

In each analysis, the regression diagnostics indicated that the assumptions of multiple-regression had been met. To aid clarity a summary regression table has been provided (see Table 3.4 below); full details of each of the regressions can be found in Appendix B, Section B.2.

Symptom reporting

Three separate hierarchical regressions were carried out, each taking total PHQ-15 as the target variable and visual performance in neutral-body, threat-scene and threat-body conditions as separate predictors in step 2, controlling for covariates (age, gender, HAI, STAI-T, STAI-S, PHQ-9, and neutral-scene visual performance) on step 1. Using this set of covariates, none of the MBT variables led to a significant improvement in the regression equation. Visual performance in the neutral-scene condition (i.e., general performance; *B* =.02, *SEB* = .01, β = .81-1.05, all *p's* <.05) and health anxiety (*B range* =7.55-7.95, *SEB*

[1]Multiple regressions predicting both symptom reporting and health anxiety without controlling for general task performance were conducted taking visual and tactile performance as predictors, the results of which can be found in Appendix B.

range = 3.50-3.59, β = .47-.49, all *p's* <.05) were unique predictors of symptom reporting in the final regression equations. Three further hierarchical regressions were then carried out using the tactile performance variables. As before, there were no significant relationships between MBT performance and symptom reporting after controlling for covariates.

These multiple-regressions revealed that visual performance in the neutral-scene condition and health anxiety were significant unique predictors of symptom reporting. The direction of the coefficients was positive, poorer visual performance and increased health anxiety were associated with increased symptom reporting.

Health anxiety

Three separate hierarchical regressions were carried out, each taking total HAI as the target variable and visual performance in neutral-body, threat-scene and threat-body conditions as separate predictors in step 2, controlling for covariates (age, gender, PHQ-15, STAI-T, STAI-S, PHQ-9, and neutral-scene visual performance) on step 1. Using this set of covariates, none of the MBT variables led to a significant improvement in the regression equation. Visual performance in the neutral-scene condition (i.e., general performance) was a significant predictor when performance in neutral-body and threat-body conditions were included as predictors *(B* range = -.00 - .00, all *SEB*= .00, β range =- .80- -.88, all *p's* <.05). Symptom reporting was also a significant predictor in each analysis (all *B* = .03, all *SEB*= .00, β range = .42-.45, all *p's* <.05).Visual performance was a negative predictor of health anxiety, suggesting better visual performance is associated with increasing health anxiety.

Three further hierarchical regressions were then carried out using the tactile performance variables. As before, there were no significant relationships between the MBT performance and health anxiety after controlling for covariates (see summary Table 3.4 below).

Table 3.4 Summary of hierarchical regressions predicting symptom reporting (PHQ-15) and health anxiety (HAI) from MBT task performance and controlling for covariates (n = 27). Full details of regressions and covariates can be found in Appendix B section B.2.

	Neutral-body			Threat-scene			Threat-body		
	B	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
PHQ-15									
Visual	-.01	.01	-.51	-.01	.01	-.26	.00	.01	.04
Tactile	.01	.01	.20	.02	.01	.59	-.01	.01	-.59
HAI									
Visual	.00	.00	.32	.00	.00	.25	1.59	.00	.02
Tactile	.00	.00	-.25	.00	.00	-.23	.00	.00	.18

*p<.05. ** p <.001.

3.5.3. *SSDT*

Does the revised thresholding procedure yield thresholds within the expected range for at least 80% of participants?

Table 3.5 below displays mean hit rates for the original threshold procedure (Lloyd et al., 2008), the more objective procedure introduced by Katzer et al. (2011), and the present study's computerised procedure. The mean hit rates are all within the 40-60% threshold range expected for single interval trials which suggests participants were thresholded in a similar way.

A further analysis of the range of hit rates in the present study revealed that 3 participants had hit rates less than 10% and two participants had hit rates greater than 90%. This suggests that the threshold procedure was less accurate for 18.5% of the sample. The hit rates and associated standard deviations (see Table 3.5) from the previous studies also show variability in hit rates. This suggests that the threshold procedures of all three studies did not accurately determine the tactile threshold in the 40-60% range for all participants. However, in the present study 81.5% of the participants thresholds were within the expected range.

Table 3.5 Mean hit rates (SD) for SSDT studies (Lloyd et al., 2008, Katzer et al., 2011 and the present study)

Study	N	Mean hit rate light-absent	Mean hit rate light present	Mean hit rate (SD) overall
Lloyd et al., (2008)	19	.52 (.15)	.66 (.14)	.59 (.14)
Katzer et al., (2011)	67	.57 (.20)	.63 (.21)	.60 (.21)
Present study	27	.52 (.22)	.67 (.25)	.59 (.24)

Does the revised thresholding procedure yield thresholds that have adequate test-retest reliability?

The test-retest correlation was r_s= .82 (p<.001), indicating that the tactile threshold was reliably determined.

Is there a significant effect of block and light on participant performance?

Table 3.6 below presents descriptive statistics for the data obtained during the experimental phase of the SSDT. In order to establish whether performance in the experimental phase of the SSDT was comparable to previous studies, hits, false alarms, tactile sensitivity (*d'*) and response bias (*c*) were first compared between the two test-halves (block 1 and block 2) and then between the two light-conditions.

Table 3.6 Block 1 and block 2: median (IQR) hit rate and false-alarm rate, mean (S.D.) d' (sensitivity) and c (response bias) light-absent and light-present conditions of the SSDT (n =27).

	% hits	% false alarms	*d'*	*c*
Block 1				
Light-absent	59.52 (45.00)	7.14 (16.00)	1.26 (.98)	.58 (.50)
Light-present	73.81 (43.00)	21.43 (24.00)	1.50 (1.29)	.22 (.58)
Block 2				
Light-absent	59.52 (38.00)	7.14 (14.00)	1.55 (1.02)	.67 (.46)
Light-present	78.57 (38.00)	11.90 (26.00)	1.68 (1.11)	.21(.43)

The effect of block

For light-absent trials, both hit rate and response bias were not significantly different between block 1 and 2. However, in block 2, false alarm rate was significantly lower and there was a non-significant trend for sensitivity to be higher (hit rate: z = -.07, p = .94; false alarm rate: z = -2.16, p = .03, r = .29, *d'*: t = -1.78, p = .09, r= .11; *c*: t = -.885, p = .385). For light-present trials there were no significant differences between block 1 and 2 for any of the SSDT variables (hit rate: z = -.49, p = .63; false alarm rate: z = 1.25, p = .21; *d*': t = -.94, p =.36; *c*: t = .08, p = .94). As there were significant differences between performance variables between block 1 and 2 in light-absent trials, the effect of the visual stimulus should be assessed for each block individually.

The effect of the visual stimulus

In block 1, participants' hit rate (z = -3.29, p = .001, r = .45), false alarm rate (z = -2.53, p = .01, r = .34) and tendency to say yes (*c*) (t = 4.35, p = .00, r = .54) were all significantly increased by the presence of the visual stimulus. However, tactile sensitivity (*d*') was not significantly increased (t = -1.62, p = .12).

The same pattern of results were also observed for block 2 (Hit rate: z = -3.63, p = .00, r = -.05; false alarm rate: z = -2.33, p = .020, r =-.32; tendency to say yes: t = 4.76, p = .00, r =.47; tactile sensitivity (*d*'): t = -.96, p = .35).

Is tactile threshold on the SSDT significantly correlated with symptom reporting or health anxiety?

Spearman's correlations were performed between average tactile threshold, symptom reporting and health anxiety and revealed no significant correlations (HAI: r_s = .02; PHQ-15: r_s = .22, both p-values >.05).

Are false alarms on the SSDT associated with symptom reporting and health anxiety?

False alarm rates were not significantly associated with symptom reporting or health anxiety[2] (see Table 3.7 below). However, the correlations between false alarms in

[2]There were also no other significant correlations between SSDT performance variables, symptom reporting and health anxiety.

both light conditions in block 2 were both > r = -.30, which represents a medium effect. It is likely that these effects were non-significant due to the low power of the study.

*Table 3.7 Zero-order correlations between: block 1 and 2 false alarms in light-absent and light-present conditions, symptom reporting and health anxiety (*n *= 27).*

	Block 1		**Block 2**	
	Light-absent	Light-present	Light-absent	Light-present
PHQ-15	-.28	-.20	-.33	-.35
HAI	-.01	.20	-.08	.08

*p < .05. ** p < .001.

Is there a significant relationship between false alarms, symptom reporting and health anxiety when controlling for age, gender, trait anxiety, anxiety and depression?

In order to further explore the relationships between false alarms, symptom reporting and health anxiety, multivariate analyses were conducted. In each analysis the regression diagnostics indicated that the assumptions of multiple-regression had been met. To aid clarity, a summary regression table has been provided (see Table 3.8 below*)*; full details of each of the regressions can be found in Appendix B, Section B.4.

Symptom reporting

Four separate hierarchical regressions were carried out, each taking total PHQ-15 as the target variable and false alarms in light-absent and present trials in block 1 and 2 as separate predictors in step 2, controlling for covariates (age, gender, HAI, STAI-T, STAI-S, and PHQ-9) on step 1. There were no significant relationships between covariates or predictors and symptom reporting.

Health anxiety

Four separate hierarchical regressions were carried out, each taking total HAI as the target variable and false alarms in light-absent and present trials in block 1 and 2 as separate predictors in step 2, controlling for covariates (age, gender, PHQ-15, STAI-T, STAI-S, and PHQ-9) on step 1. There were no significant relationships between covariates or predictors and health anxiety.

*Table 3.8 Summary of hierarchical regressions predicting symptom reporting (PHQ-15) and health anxiety (HAI) from false alarms on blocks 1 and 2 of the SSDT controlling for covariates (*n = *27). Full details of regressions and covariates can be found in Appendix B, Section B.4.*

	Block 1			Block 2		
	B	*SEB*	*β*	*B*	*SEB*	*β*
PHQ-15						
Light-absent	-2.98	4.91	-.14	-5.01	4.41	-.24
Light-present	-2.97	3.40	-.18	0.04	0.21	.04
HAI						
Light-absent	-0.11	0.29	-.08	-0.16	0.27	-.12
Light-present	0.20	0.19	.20	0.04	0.21	.04

*p<.05. ** p <.001.

3.5.4. *SSDT & MBT*

Are tactile threshold, false alarms and MBT performance significantly correlated with one another?

Spearman's correlations were performed between block 1 and 2 false alarms in light-present and light-absent trials, tactile threshold (Average of pre and post experimental trials) and MBT performance, and revealed no significant associations (see Table 3.9 below). However, correlations between visual performance and false alarms yielded medium effects; it is likely that these effects were non-significant due to low power.

*Table 3.9 Zero-order correlations between MBT variables and SSDT variables (*n = *27).*

	Block 1		Block 2		Average
	Light-absent FA	Light-present FA	Light-absent FA	Light-present FA	Tactile threshold
Tactile targets					
-Neutral-body	-.12	-.18	-.20	-.18	-.05
-Neutral-scene	-.15	-.19	-.21	-.22	-.05
-Threat-body	-.13	-.28	-.22	-.27	-.20
-Threat-scene	-.01	-.10	-.10	-.25	-.07
Visual targets					
- Neutral-body	-.25	-.31	-.34	-.34	.02
- Neutral-scene	-.27	-.28	-.30	-.29	.15
- Threat-body	-.26	-.26	-.37	-.28	.11
- Threat-scene	-.20	-.28	-.30	-.25	-.05

*p<.05. ** p <.001

3.6. Discussion

The aims of this study were twofold. The first aim was to assess the validity and reliability of the modified MBT and SSDT. The second aim was to investigate the relationships between attention (MBT performance), somatic awareness (tactile threshold and false alarms), symptom reporting and health anxiety.

As this was a pilot study, the sample size was small and this clearly limits the potential reliability of the findings. The questionnaire measures indicated that the sample was relatively healthy. Symptom reporting levels were low and so do not allow generalisations to be made to clinically relevant levels of symptom reporting. In addition, the reliability of the PHQ-15 was poor in this sample, further limiting the conclusions that can be drawn. The results need to be interpreted with these caveats in mind.

3.6.1. *MBT*

Participant threat ratings of the pictures presented in the MBT confirmed that body and scene pictures in neutral and threatening conditions were matched on perceived threat level and that neutral pictures were rated as significantly less threatening. This indicated that the revised picture set was clearly recognisable within the short presentation period and that the manipulation was appropriate. None of the participants reported being distressed by the pictures or indeed any aspect of the task; this suggests that the task is acceptable for use in future research.

In reaction time tasks visual performance is often slower than tactile performance as transduction (the transmission of sensory messages to the brain) is longer for vision at around 50 ms (Schnapf, Kraft & Baylor, 1987), than for touch at around 2 ms (Mizobuchi et al., 2000). Thus a significant difference in performance between modalities would be expected. In the present study performance for visual targets was significantly poorer than performance for tactile targets, irrespective of picture condition, resulting in a positive tactile bias in all picture conditions. These findings are consistent with prior expectations regarding performance for visual and tactile targets. They are also consistent with the results of the original MBT study, which also found a significant tactile bias for all picture conditions.

There was a significant interaction between picture-type and picture-valence with visual target performance being significantly poorer following threatening body-relevant pictures than threatening body-irrelevant pictures. There was also a trend for both visual and tactile performance in the neutral body-relevant condition to be better than performance in the threatening body-relevant condition. This effect would probably have been significant with more participants, and warrants further investigation with a larger sample. As there were no significant interactions between target-type and either picture-type or picture-valence, it appears that the picture cues affected the subsequent detection of both tactile and visual targets in a similar way. The present findings are in line with the findings of the original MBT study. Taken together these results provide evidence of the reliability and validity of the task as a measure of attentional processes which may be relevant to symptom reporting and health anxiety.

Both symptom reporting and health anxiety are hypothesised to be associated with a body-focused attentional bias (Pennebaker, 1982; Barsky & Wyshack, 1990; Rief & Barsky, 2005). In support of this hypothesis, the original MBT study found that non-

clinical pseudo neurological symptom reporters displayed a greater tactile bias, than low-symptom reporters, following threatening body-relevant pictures only. However, visual and tactile performance was not analysed separately, rendering the exact source of the significant tactile bias unclear. It is possible, for example, that shifting within modalities (i.e. from the visual cue to the visual target) results in slower performance relative to shifting between modalities (i.e. from the visual cue to the tactile target; Hanson, Whitaker, & Heron, 2009). If so, positive tactile bias may actually reflect greater difficulty in disengaging from the cue, which may be more pronounced in the visual modality where visual disengagement is required to detect subsequent visual targets. Indeed, previous studies have found MUS to be associated with difficulties disengaging visual attention from stimuli (Roelofs et al., 2003; Rief & Auer, 2001). For this reason, tactile and visual performance were analysed separately as well as together in this study.

Tactile bias in neutral-body and neutral-scene conditions was significantly associated with symptom reporting. This seems to suggest that symptom reporting is associated with a tendency to be quicker and more accurate at detecting tactile targets relative to visual targets, consistent with increased body-focus under neutral conditions. However, symptom reporting was also associated with both poorer visual and tactile performance, which is more consistent with a disengagement interpretation. Indeed, the results of the regression analyses suggest that the relationship between tactile bias and symptom reporting was mainly driven by the association between poorer visual performance and symptom reporting. Taken together, these findings suggest that problems with visual disengagement are the source of the association between symptom reporting and tactile bias rather than body-focus.

When controlling for age, gender, health anxiety, trait anxiety, current anxiety and depression, visual performance in the neutral-body-irrelevant condition remained a significant predictor of symptom reporting (neutral and threatening body-relevant conditions were near significant predictors). This finding was unexpected as performance in the neutral body-irrelevant condition, unlike the threatening body-relevant condition, has not previously been found to be related to symptom reporting (Brown, Poliakoff & Kirkman, 2007). This finding suggests that under neutral conditions symptom reporting is associated with delayed visual disengagement from the cue. Ageing is associated with slower and more variable RT's in general (Luchies et al., 2002; Rose et al., 2002; Hultsch et al., 2002). It is likely that the simpler neutral condition allowed the relationship between age, symptom reporting and task performance to be observed, which would

explain why the independent associations were only found in this condition. This finding highlights a potential difficulty with employing measures of target performance, which are predominately based on RT, to investigate attentional effects.

In order to control for general task performance, neutral-scene performance was also included as a covariate. The addition of visual and tactile performance in neutral-body, threat-body and threat-scene conditions did not improve the model of symptom reporting. Poorer visual performance in the neutral-scene condition and health anxiety remained independent predictors of symptom reporting. This suggests that poorer visual performance and higher levels of health anxiety may be independently associated with increased levels of non-clinical symptom reporting.

Health anxiety has also been associated with attentional biases for health related material (see Chapter 2 Section 2.5 for a full discussion). A recent dot-probe study by Jasper and Witthöft (2011), found those with health anxiety displayed both hypervigilance for, and delayed visual disengagement from, threatening health-related pictures. In the present study when controlling for covariates and general task performance, the addition of threat-body and threat-scene tactile and visual performance did not significantly improve the model of health anxiety. However, better visual performance in the neutral-scene condition and symptom reporting were unique predictors of health anxiety.

The close association between health anxiety and symptom reporting and the lack of clear evidence regarding their development and maintenance has led some to suggest that they refer to the same underlying processes (Creed & Barsky, 2004). The present findings indicate that symptom reporting may be associated with poorer visual performance and that health anxiety may be associated with better visual performance. These relationships were independent of one another as well as gender, age, trait anxiety, anxiety and depression. This finding is interesting as it suggests that symptom reporting and health anxiety are associated with opposite attentional processes. Findings such as this may help to differentiate the processes underlying these highly related constructs.

3.6.2. *SSDT*

The mean light-absent hit rate in block 1 was within the 40-60% range for single interval trials. Thus, the probability of detecting the tactile stimulus was above chance, but the task remained difficult enough to induce uncertainty. However, around 15% of participants had light-absent hit rates greater than 90% and lower than 10% respectively.

Variability around the threshold is expected and is unavoidable since some participants' threshold will be at the bottom end (e.g. 40%) of the threshold whilst some will be at the top end (e.g. 60%). Furthermore, the introduction of the more objective threshold procedure means that the tactile stimulus is arrived at without the effects of response bias. When completing the experimental trials, response bias is reintroduced and this may further reduce or enhance hit rates. For around 85% of the sample the computerised procedure resulted in thresholds within the expected range. The results therefore provide acceptable evidence for the validity of the revised threshold procedure. The high test-retest correlation indicated that thresholds were reliably determined. Taken together these results indicate that the computerised threshold procedure is both valid and reliable. Further testing in a larger sample will determine whether the threshold procedure is similarly effective for the majority (> 80%) of participants.

There was a significant effect of test half on light-absent false alarms such that they decreased in block 2. There was also a trend for light-absent tactile sensitivity to increase in block 2. Hit rates and response bias remained stable across test halves, however. Although differences between test halves have not been reported in the majority of SSDT studies, a similar pattern was reported by Katzer et al., (2011), who also found a decrease in false alarms on the second test half in a student sample. This finding suggests that the tendency to experience somatic distortion (false alarms), although having been found to be a relatively stable trait-like characteristic, maybe subject to task influences. This reduction in somatic distortions could be due to task practice. As response bias remained relatively stable this decrease would seem to be attributable to better judgment of when the stimulus was absent. This finding indicates that in future SSDT studies test halves should be analysed separately.

In line with previous SSDT studies, the presentation of the light increased hit rates, false alarms and the tendency to say yes (Lloyd et al., 2008; Brown et al.,2010). However, the light did not augment tactile sensitivity, which has been found in some SSDT studies (Brown et al., 2010; Brown et al., 2012 (study 2); Katzer et al., 2012), but not in others (Lloyd et al., 2008; Brown et al., 2012; Katzer et al., 2011). The lack of increase for tactile sensitivity suggests that the main effect of the light is on later decision making processes, with any effect on early perceptual processes being very small. The effect of the light was consistent across both test halves suggesting a robust effect. The validity of the threshold procedure is further supported by the significant effects of the light.

Tactile threshold was not related to symptom reporting or health anxiety. This evidence suggests that neither symptom reporting nor health anxiety is associated with an enhanced ability to detect subtle somatosensory signals. The present findings are in contrast to a recent study by Katzer et al., (2012) who found that SFD patients had lower tactile thresholds than healthy controls. The results of the present study do not support the model of Rief and Barsky (2005), which hypothesises that decreases in a somatosensory filtering mechanism increases the perception of physical symptoms. Nor do they support a somatosensory amplification model of health anxiety and symptom reporting (Barsky & Wyshak, 1990). According to both accounts high symptom reporters and those high in health anxiety should be able to detect subtle sensations at reduced levels.

There was a near significant negative association between false alarms in both light conditions on block 2 of the SSDT and symptom reporting. These results suggest a reduced tendency to experience somatic distortions was associated with increased symptom reporting, particularly in block 2. This relationship may account for the significant reduction in false alarms observed in block 2. This finding is in contrast to previous studies in student populations which have found positive associations between symptom reporting (Brown et al., 2010; Brown et al., 2012, Katzer et al., 2011) and health anxiety (Katzer et al., 2013). It is noteworthy, however, that those SSDT studies that have found somatic distortion to be associated with symptom reporting had a greater range of symptom reporting than in the present study. A positive association may not have been found here because of the low levels of symptom reporting coupled with the low reliability of the PHQ-15, which are likely due to the small sample size.

3.6.3. *Attention and somatic awareness*

None of the measures of attention were significantly related to the tendency to experience distortions in somatic awareness or tactile threshold. However, there were near significant negative relationships between visual performance and false alarms in both light conditions in the second test-half. That is, difficulty disengaging visual attention from picture cues was associated with a reduced tendency to experience somatic distortions on block two of the SSDT. The Brown model suggests that both delayed disengagement from symptom relevant material and a greater tendency to experience distortions in somatic awareness may be associated with symptom reporting. However, the model makes no claims about the relationship between delayed disengagement and somatic distortion. This

finding suggests that the two processes may be related to one another in non-clinical symptom reporters and warrants further investigation to check that it is reliable.

3.6.4. *Strengths, limitations and future directions*

A more comprehensive analysis of MBT performance and its relationship with symptom reporting and health anxiety has further clarified the nature of the task. The task was found to be both a valid and reliable measure of disengagement from different types of visual cue. The tactile bias measure, however, does not appear to provide a measure of body-focused attention. These findings provide preliminary evidence that there may be relationships between delayed disengagement and symptom reporting and enhanced disengagement and health anxiety. The MBT was therefore carried forward to the Primary care study.

A fully computerised, forced choice adaptive threshold procedure was successfully introduced to the SSDT. The procedure was found to be both valid and reliable. Although no significant relationships were found between the tendency to experience somatic distortions, symptom reporting or health anxiety in the present study, there is a growing body of evidence that suggests there are significant positive relationships between these variables. The current non-significant negative association is likely due to the low levels of symptom reporting and poor reliability of the symptom reporting measure in this sample.

Piloting in the student sample has resulted in the development of two valid and reliable paradigms which may be employed to measure attention and somatic awareness in future research. The present study has been limited by the low levels of physical symptoms reported, the poor reliability of the symptom reporting measure, and a lack of power due to the small sample size. Further longitudinal research with larger samples reporting clinically relevant levels of symptoms are required to adequately test hypotheses regarding the relationships between attention, somatic awareness, physical symptom reporting and health anxiety.

Chapter 4. Attention, symptom reporting and health care utilisation in primary care patients - A cross-sectional and longitudinal study

4.1. Introduction

Chapters 4, 5 and 6 describe the results of a prospective study carried out with participants recruited from primary care. Participants completed the MBT, SSDT and a battery of questionnaires at baseline (T1). They repeated the same measures at 6 month follow-up (T2). In this chapter the recruitment process and procedure of the study are outlined. A description of the sample is also given and the results of the MBT are presented. In chapter 5, the results of the SSDT are presented. Chapter 6 provides a structural equation modeling (SEM) analysis of the study data. As the results of the MBT are discussed in this chapter, evidence regarding the relationship between attention, symptom reporting and health anxiety is described briefly below.

4.1.1. *Attention, symptom reporting and health anxiety*

As discussed in Chapter 1 (Section 1.6) and Chapter 2 (Section 2.5 & 2.11), Biopsychosocial models generally propose a body-focused attentional bias and specific biases for illness-related information (Pennebaker, 1982; Barsky, & Wyshak, 1990; Cioffi, 1991; Rief & Barsky, 2005). Later cognitive-attentional (Brown, 2004) and neurobiological models (Edwards et al., 2012) have implicated attentional biases specifically for symptom representations or abnormal illness beliefs, rather than a general body-focused bias per se. However, how such attentional effects might manifest themselves has not been clearly stated (Miles, 2009).

Empirical studies have found MUS to be associated with difficulties disengaging visual attention from neutral (Roelofs et al., 2003; Rief & Auer, 2001) and threatening stimuli (Hou, Moss-Morriss, & Bradley, 2008). Non-clinical symptom reporting has also been associated with a body-focused bias following threatening body-relevant material (Brown, Poliakoff & Kirkman, 2007). However, the findings of the previous chapter suggest that the results of Brown, Poliakoff and Kirkman, (2007) may in fact indicate that high symptom reporters have difficulties disengaging visual attention from threatening body-relevant material. More recently health anxiety has been associated with both hypervigilance for, and delayed disengagement from, symptom relevant material (Jasper & Witthöft, 2011). Taken together, these results suggest that difficulties disengaging visual

attention from neutral stimuli may be associated with symptom reporting, whilst difficulties disengaging visual attention from symptom relevant stimuli may be associated with both symptom reporting and health anxiety. Difficulties disengaging from both neutral and threatening stimuli would suggest a more general deficit in attention; whereas difficulties disengaging specifically from symptom-relevant material would suggest a more specific bias in selective attention.

Whilst there is some limited evidence that symptom reporting and health anxiety are associated with delayed disengagement in the visual modality, less evidence exists regarding delayed disengagement effects in the tactile modality. Research employing tactile targets might provide more direct evidence for a body-focused attentional bias. A recent study by Brown et al., (2010) found that following a neutral film, high symptom reporters displayed delayed disengagement from tactile cues compared to low symptom reporters. Following a trauma film, however, high symptom reporters displayed avoidance of the tactile stimuli. This evidence suggests that emotional state may affect attention to the body and that high symptom reporting may also be associated with delayed disengagement in the tactile modality.

The evidence summarised here suggests that delayed disengagement effects may be observed in both modalities, however, there have been no published studies that assess disengagement from neutral and threatening material in both the visual and tactile modality simultaneously. Furthermore, the studies discussed here have all been cross-sectional in nature, thus the direction of causality between disengagement effects, symptom reporting and health anxiety has yet to be established.

It is also not known whether disengagement effects are related to health care utilisation. Models of both MUS and health anxiety suggest that reassurance seeking, which usually involves health care utilisation, is an important maintaining factor in such presentations (Pennebaker, 1982; Barsky & Wyshak, 1990; Rief & Barsky, 2005; Brown, 2004, Deary et al., 2007), however, evidence for this is lacking. Greater understanding of the psychological processes that predict, symptom reporting, health anxiety and health care utilisation may help improve psychological treatments.

To this end a prospective study was carried out, with participants recruited from primary care, to evaluate the relationships between attention (MBT), somatic awareness (SSDT), symptom reporting, health anxiety and health care utilisation.

4.2. Study aims and research hypotheses

The aims of the prospective study were two-fold. The first aim was to further investigate the processes measured by the MBT and SSDT. Thus a preliminary analysis of MBT performance involved establishing (i) whether the MBT picture set provided an effective manipulation (i.e., that neutral pictures were rated as significantly less threatening and that body and scene pictures in neutral and threatening conditions were matched on perceived threat level); and (ii) what effect the picture cues had on performance.

The second aim was to investigate whether attention (MBT performance) and somatic awareness (SSDT performance) were associated with symptom reporting, health anxiety and health care utilisation both cross-sectionally and longitudinally.

Biopsychosocial, cognitive-attentional and neurobiological models have made quite general predictions regarding the attentional effects expected to be associated with symptom reporting and health anxiety. It is therefore difficult to derive specific hypotheses from these models regarding the type of disengagement effects expected on the MBT. In line with biopsychosocial model predictions (i.e., a general body-focused bias, as well as, specific biases for symptom relevant material), we might expect tactile disengagement effects across all conditions and visual disengagement effects in the threatening body-relevant condition to be associated with symptom reporting, health anxiety and health care utilisation. In contrast, cognitive-attentional (Brown, 2004) and neurobiological models (Edwards et al., 2012) would predict that symptom reporting, health anxiety and health care utilisation are associated with disengagement effects in the threatening body-relevant condition only.

The results of the MBT discussed in the previous chapter demonstrated that under neutral conditions, delayed visual disengagement was associated with symptom reporting and enhanced visual disengagement was associated with health anxiety. However, previous research employing the MBT has also found attentional effects specifically in the threatening-body relevant condition to be associated with high symptom reporting (Brown, Poliakoff & Kirkman, 2007). A secondary analysis of MBT performance therefore involved testing the following hypotheses: (i) that there would be significant positive correlations between disengagement and symptom reporting; (ii) there would be significant negative correlations between disengagement and health anxiety; that these relationships would be significant both (iv) cross sectionally, (v) longitudinally, (vi) and

would remain after controlling for age, gender, medical conditions, trait anxiety, anxiety and depression.

We also had the following exploratory aims: to investigate whether (i) visual and tactile performance was associated with health care utilisation both (ii) cross sectionally, (iii) longitudinally, and (iv) independently of age, gender, medical conditions, symptom reporting, health anxiety, trait anxiety, anxiety and depression.

4.3. Method

4.3.1. *Recruitment and procedure*

Ethical approval was obtained from the NHS NRES committee North West – Greater Manchester East (REC ref. No.: 11/NW/0377) and the University of Manchester ethics committee (Ref. No.: 11209). Participants were recruited from seven general practices in central Manchester between October 2011 and January 2013. Posters advertising the study were placed in practice waiting areas; participants were approached by researchers in practice waiting rooms and given study information. Participants could either indicate their interest in participating directly to the researcher; or by post; email/telephone. Those who indicated that they were interested in participating were contacted a minimum of 24 hours later by email or telephone. Participants were excluded if they were unable to read and write English, had any major sensory impairment or did not meet the age criteria (18-50 yrs). Those who were eligible and who agreed to take part were booked a research appointment and were sent a questionnaire pack (questionnaire pack 1 contained measures of: demographics, chronic medical conditions, health care utilisation and trait anxiety; for details of the questionnaires see Section 4.3.2 below) to complete at home and bring with them to their appointment.

At the first research appointment, participants provided written informed consent in accordance with NHS ethical guidelines. Participants completed a second questionnaire pack (questionnaire pack 2 contained measures of: symptom reporting (PHQ-15) and health anxiety (HAI)), the SSDT (see Ch. 3, Section 3.3.5 for SSDT procedure), the brief symptoms inventory (BSI; see Section 4.3.2); and finally the MBT (see Ch. 3, Section 3.3.4). The same procedure was followed at 6 month follow-up. The first session took approximately 2 hours and the second session approximately 1.5 hours. Participants received a £10 voucher at the end of each completed session.

4.3.2. *Questionnaires*

Two bespoke self-report questionnaires were used to measure demographics and health care utilisation (see Appendix A for a copy of both questionnaires). The demographics measure assessed: age, sex, ethnicity, marital status, education and employment. A bespoke measure of health care utilisation was developed, rather than using an existing measure from health economics, in order to capture information about health care utilisation from a patient perspective across a wide range of settings. The health care utilisation measure consisted of 14 items, nine of which pertained to healthcare utilisation of private and public health services across primary, secondary and tertiary care settings, as well as, complimentary services. A further five items pertained to costs to patients for health related items, such as, prescriptions and vitamins, however, costs were not analysed in this thesis.

The effects of chronic health conditions were controlled for using the Charlson comorbidity index (CCI; Charlson, 1983). Respondents either respond 'no' or 'yes' to 14 items assessing the presence and severity of 12 chronic conditions (cardiovascular disease, vascular disease, stroke, chronic lung disease, diabetes, kidney disease, liver disease, stomach ulcers, cancer, Alzheimer's disease, rheumatic or connective tissue disease and HIV/AIDS). This measure can be used to give a weighted measure of the risk of mortality. As very few people in this study had chronic health conditions, and if they did they typically had only one condition, it was used as a dichotomous variable with 0 indicating that a chronic condition was not present and 1 indicating the presence of a chronic condition.

In order to control for the effects of trait anxiety, the trait-component of the state-trait anxiety measure (STAI-T; Speilberger, 1983) was employed (see Chapter 3, Section 3.5.1 for details of the STAI-T).

Depression and anxiety were assessed and controlled for using the brief symptom inventory (BSI; DeRogatis, 1993). The BSI asks respondents to indicate the degree to which they have been bothered by 53 symptoms which relate to 9 psychological dimensions (somatisation, obsessive-compulsive behaviour, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism) in the last seven days. Respondents use a 5-point scale ranging from 0 ('not at all') to 4 ('extremely'). Responses are scored from 0-4 and higher scores indicate greater levels of

distress. The scale reliability in the original validation report for depression was Cronbach's α=0.85 and for anxiety was Cronbach's α=0.81).

4.4. Description of the sample

4.4.1. *Participants*

A total of 129 participants were initially recruited, however, 3 participants were excluded (two had major sensory impairments and one did not meet the age criteria); the remaining 126 were sent a questionnaire pack and booked an initial appointment. Of those, 109 attended the first appointment (T1), and 72 returned for their six month follow-up (T2); the flow of participants through the study is detailed in Figure 4.1 below. Reasons why participants did not attend their baseline or 6 month follow-up appointment were not recorded because contact could not be established with the majority of these participants.

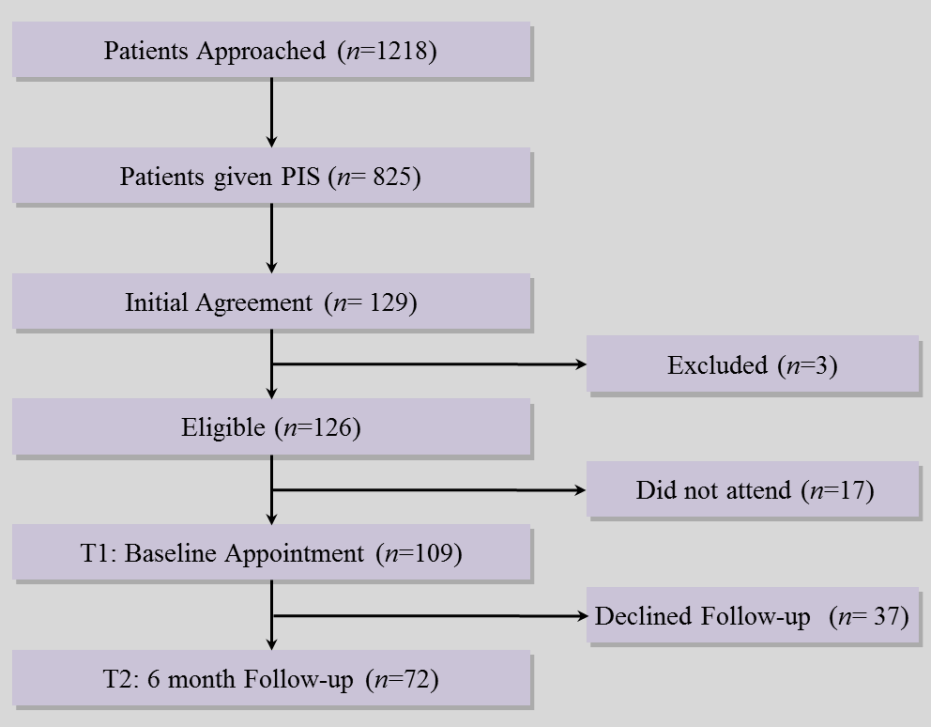

Figure 4.1 Diagram showing participant flow through the study.

Socio-demographic characteristics of the study sample are presented in Table 4.1 below. At T1 three quarters of the sample were female (75.2%), the mean age was 30.11 years (SD 9.97) and 67% described themselves as white British. Fifteen patients were unemployed and 64% were single. The majority of the sample had been educated to at least age 16 years (99.0%). At T2 just under three quarters of the sample were female (70.8%),

the mean age was 30.04 years (SD 9.64) and 72.2% described themselves as white British. Nine were unemployed and 66.6% were single. The majority of the sample had been educated to at least 16 years (98.6%). Thus the socio-demographic characteristics of the sample at T2 were very similar to those at T1.

*Table 4.1 Socio-demographic characteristics of the study sample at T1 (*n*= 109) and T2 (n= 72).*

Characteristic	T1:	T2:
	n (%) or mean±SD	*n* (%) or mean±SD
Female	82 (75.2)	51 (70.8)
Age (years)	30.11 ±9.97	30.04 ±9.64
White British	73 (67.0)	52 (72.2)
Black British	2 (1.8)	3 (4.2)
Asian British	5 (4.6)	2 (2.8)
White other	15 (12.8)	9 (12.5)
Black African	2 (1.8)	2 (2.8)
Asian other	4 (3.7)	2 (2.8)
Chinese other	3 (2.8)	2 (2.8)
Other	4 (3.4)	2 (2.8)
Unemployed	15 (13.8)	9 (12.5)
Single	70 (64.2)	48 (66.7)
Education 16+	108 (99.1)	71 (98.6)

Clinical characteristics of the sample can be found in Table 4.2 below. At T1, 65.1% of the sample reported that they were taking some form of prescribed medication and at T2 this figure was 59.7%. The three most commonly reported medications taken by patients at both time points were anti-asthmatics, anti-depressants and oral contraceptives. At T1, 31 participants self-reported the presence of at least one medical condition, and at

T2, this figure was 22. The three most commonly reported medical conditions at both time points were asthma, rheumatic/connective tissue disease and diabetes.

Table 4.2 Clinical characteristics of the study sample at T1 (n= 109) and T2 (n= 72).

Characteristic	T1:	T2:
	n (%)	*n* (%)
Currently taking prescribed medication	71 (65.1)	43 (59.7)
Anti-asthmatic	28 (25.7)	14 (19.4)
Anti-depressant	18 (16.5)	16 (23.2)
Oral-contraceptive	18 (22.0)	12 (24.5)
Self-reported medical conditions	31 (28.4)	22 (30.6)
Diabetes	4 (3.7)	3 (2.8)
Kidney disease	1 (0.9)	1 (1.4)
Stomach ulcer	2 (1.8)	2 (1.8)
Cancer:	2 (1.8)	2 (1.8)
Lung (current)	1	1
Brain tumour (past)	1	1
Asthma	22 (20.2)	14 (19.4)
Rheumatic/connective tissue disease	4 (3.7)	1 (1.4)

Behavioural and psychological characteristics of the sample are displayed in table 4.3 below. At T1, the median number of contacts made with health care professionals (HCU) over a six month period was 12.0; at T2 this figure was 7.00. At T1 26 participants reported clinically relevant levels of symptom reporting (PHQ-15) and at T2 this figure was 20 (PHQ-15 scores > 10 indicate clinically relevant levels; Körber et al., 2011). At T1 32 participants reported clinically relevant levels of health anxiety (HAI), at T2 this figure was 17 (HAI scores > 18 indicate clinically relevant levels; Salkovskis et al., 2002). Levels

of trait anxiety (STAI-T), state anxiety (BSI-A) and depression (BSI-D) were relatively low at both T1 and T2. Cronbach's α indicated that the reliability of the measures was very high (α range =.78-.94) at both time points.

A series of one way ANOVAs and chi-squared tests of difference were performed to check for significant differences in, clinical, behavioural and psychological characteristics of those who did and did not attend at T2 and revealed no significant differences (all *p*'s>.05). Of those participants who did attend both T1 and T2 appointments, levels of health anxiety (t = -29.33, 70, p = .00, r = .98) and health care utilisation (t = -2.52, 70, p = .01, r = .28) were significantly higher at T2. There were no other significant changes between T1 and T2 questionnaire measures.

Table 4.3 Behavioural and psychological characteristics of the study sample at T1 (n= 109) and T2 (n= 72).

	T1:			**T2:**			
Measure	**mean±SD or median±IQR[a]**	**Cronbach's α**	**Range**	**mean±SD or median±IQR[a]**	**Cronbach's α**	**Range**	**Possible range**
HCU	12.00±10.50[a]	-	0-89	7.00±12.00	-	0-62	-
PHQ-15	7.00±6.00[a]	.78	0-26	7.00±6.25[a]	.80	0-23	0-30
HAI	13.00±9.00[a]	.83	0-24	13.50±8.50[a]	.87	0-34	0-54
STAI-T	44.81±11.20	.92	24-44	42.69±11.49	.94	22-75	20-80
BSI-A	4.00±8.00[a]	.87	0-24	3.00±5.50[a]	.88	0-24	0-24
BSI-D	4.00±6.50[a]	.89	0-24	4.00±7.00[a]	.91	0-24	0-24

[a] *Median and interquartile range are shown because of the non-normality of the data.*

4.5. Statistical analysis

4.5.1. *Data preparation*

Although 109 participants were tested at T1, data from 104 participants was included in the final MBT sample for the following reasons: four participants did not complete the MBT (two because they felt unwell, one because of time constraints and one because the equipment failed during testing). In addition, one participant made the

incorrect response ten times in one stimulus condition, which suggests they were not completing the task in the same way as the other participants (mean total errors = .91). Seventy-two participants returned at follow-up, however 70 were included in the final MBT sample as two participants did not complete the task (1 because they were unwell, and 1 because of time constraints).

Prior to analysis, the data from the MBT was prepared using the same outlier removal procedure as detailed in Chapter 3 (Section 3.4.1). This resulted in the removal of 5.7% and 5.0% of trials at T1 and T2 respectively. Tactile and visual performance (inverse efficiency) in each picture condition was calculated in the same way as detailed in Chapter 3, Section 3.4.1, the tactile bias measure, however, was not calculated.

4.5.2. *Data distribution*

Both questionnaire and task data were screened for normality. Non-normal variables (see Appendix C, Section C.1 for full details) were transformed using log and square root transformations as appropriate, following the recommendations of Tabachnick and Fiddell (1996). The following variables were non-normally distributed and could not be transformed (T1: age; gender; CCI; BSI-A; BSI-D; all picture threat ratings; T2: age; gender; CCI; BSI-A; BSI-D; all picture threat ratings). Therefore non-parametric tests were used in the analysis of these variables.

4.5.3. *Analyses addressing study aims and hypotheses*

Primary analyses. A manipulation check was performed on the subjective threat ratings of the pictures, using Wilcoxon matched-pairs tests. Repeated measures ANOVAs and t-tests were used to analyse the effect of the picture cues on MBT performance. This analysis was conducted cross-sectionally at both T1 and T2.

Secondary analyses. In order to address the study hypotheses, correlations were conducted between MBT performance and sample characteristics. Hierarchical multiple regressions, controlling for relevant covariates (age, gender, CCI, STAI-T, BSI-Anx, BSI-Dep), were conducted to evaluate whether MBT performance was independently associated with symptom reporting, health anxiety, and health care utilisation. Total PHQ-15, total HAI and total HCU score were the target variables; MBT performance was analysed for each picture condition separately. This analysis was conducted cross-sectionally and longitudinally (T1 visual and tactile performance on the MBT were taken

as predictors, T1 variables were taken as covariates and T2 total PHQ15 score, HAI score and HCU score were the target variables).

Overall. Two-tailed tests of significance are reported throughout, an alpha level of .05 was used, and measures of effect size are all Pearson's *r,* or for non-parametric correlations Spearman's *r; r*≥.10 was considered a small, *r*≥.30 a medium, and *r*≥.50 a large effect. All statistical analyses were conducted using SPSS version 20.0 (IBM SPSS Inc., Chicago, IL).

4.6. Primary analysis

4.6.1. *Baseline (T1) results*

Is the threat manipulation effective?

The median threat ratings for the picture conditions were: neutral-scene, .00; neutral-body, .00; threat-scene, 6.00; threat-body, 5.43. Threat pictures were rated as significantly more threatening than neutral pictures for each category (threat-scene & neutral-scene: z = -8.77, p = .00, r = -.61; threat-body & neutral-body: z = -8.85, p = .00, r = -.61), and both differences yielded large effect sizes. Neutral-body pictures were rated as significantly more threatening than neutral-scene pictures (z = -2.48, p = .12, r = -.17), and threat-scene pictures were rated as significantly more threatening than threat-body pictures (z = -3.36, p = .001, r = - .23), however, both differences yielded small effect sizes. The threat ratings indicate that the manipulation was appropriate.

What effect did the picture cues have on performance?

Mean tactile and visual performance (IE) in each of the picture conditions is displayed in Figure 4.2 below.

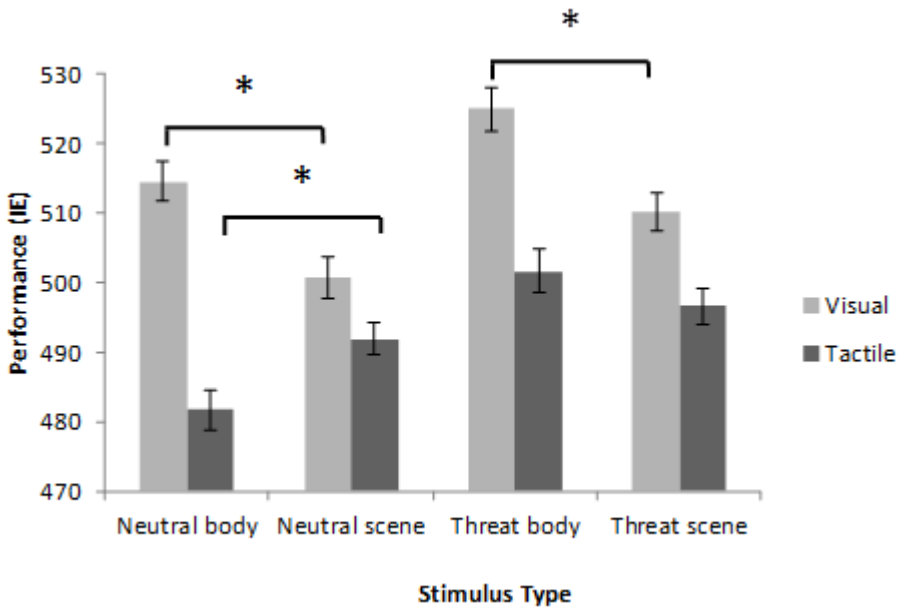

*Figure 4.2 Adjusted mean (SE) visual and tactile performance (IE) for each stimulus type (note * indicates significant difference (*p< .05)[3]).*

The transformed performance data were analysed with a 2 (picture-valence: neutral vs. threatening) x 2 (picture-type: body vs. scene) x 2 (target-type: tactile vs. visual) within-participants repeated measures ANOVA. There were highly significant effects of picture-valence (F, (1, 103) = 3491.55, p < .001, η^2 = .97), with poorer performance following threatening pictures than neutral pictures (neutral mean = 497.25; threat mean = 508.36), picture-type (F, (1, 103) = 3492.22, p < .001, η^2 = .97), with poorer performance following body-relevant pictures than body-irrelevant pictures (body mean = 505.72; scene mean = 499.89) and target-type (F, (1, 103) = 3493.00, p < .001, η^2 = .97), with poorer performance for visual targets than tactile targets (tactile mean = 492.97; visual mean = 512.64). There were highly significant picture-type × picture-valence (F, (1, 103) = 3493.28, p < .001, η^2 = .97), picture-valence × target-type (F, (1, 103) = 3492.87, p < .001), picture-type × target-type (F, (1, 103) = 3493.22, p < .001, η^2 = .97) and picture-type × picture-valence × target-type interactions (F, (1, 103) = 3492.39, p < .001, η^2 = .97). The three-way significant interaction was followed-up with ANOVAs conducted separately for tactile and visual targets.

[3] To aid clarity not all significant differences have been included in the figure, see analysis below for full details of significant differences.

For visual performance there were highly significant main effects of picture-valence (F, (1, 103) = 3492.21, $p < .001$, $\eta^2 = .97$), with poorer visual performance following threatening pictures than neutral pictures (threat mean = 517.04; neutral mean = 507.38), and picture-type (F, (1, 103), 3492.72, $p < .001$, $\eta^2 = .97$), with poorer visual performance following body-relevant pictures than body-irrelevant pictures (body mean = 519.36; scene mean = 505.06). There was also a highly significant picture-valence × picture-type interaction (F, (1, 103) = 3492.84, $p < .001$, $\eta^2 = .97$).

Follow-up t-tests revealed that visual performance following neutral body-irrelevant pictures was significantly better than performance following neutral body-relevant pictures (t = -59.10, 103, $p < .001$, $r = .98$), with a large effect. Visual performance following threatening body-irrelevant pictures was significantly better than performance following body-relevant pictures (t = 2.69, 103, $p < .01$, $r = .26$), with a small to medium effect. These results suggest that better visual performance in the neutral body-irrelevant and threatening body-irrelevant condition were the source of the significant valence × picture type interaction.

For tactile performance there was a highly significant main effect of picture-valence (F, (1, 103) = 14.60, $p < .001$, $\eta^2 = .12$) with poorer tactile performance following threatening pictures than neutral pictures (threatening: mean = 499.12; neutral: mean = 486.82). There was a non-significant effect of picture-type (F, (1, 103) = .55, $p > .05$), however, there was a significant picture-valence × picture-type interaction (F, (1, 103) = 7.42, $p < .01$, $\eta^2 = .07$).

Follow-up t-tests revealed that tactile performance following neutral body-relevant pictures was significantly better than tactile performance following neutral body-irrelevant pictures (t = -2.71, 103, $p = .01$, $r = .26$). There were no significant differences between tactile performance following threatening body-relevant and irrelevant pictures (t = 1.28, 103, $p = .20$). These results suggest that better tactile performance in the neutral body-relevant condition was the main source of the significant valence × picture type interaction.

4.6.2. *6 month follow-up results (T2)*

Is the threat manipulation effective?

The median threat ratings for the picture conditions were: neutral-scene, .06; neutral-body, .13; threat-scene, 6.50; threat-body, 4.75. Threat-scene and body pictures were rated as significantly more threatening than neutral-scene and body pictures (threat-

scene & neutral-scene: z = -7.04, p <.001, r = -.60; threat-body & neutral-body: z = -7.17, p <.001, r = -.61) and both differences yielded a large effect size. The threat ratings indicate the manipulation was appropriate. Neutral-body and neutral-scene pictures were not significantly different on perceived threat level (z = -.73, p > .05). Threat-scene pictures were rated as significantly more threatening than threat-body pictures (z = -3.41, p = .001, r = -.29) and yielded a small to medium sized effect.

In line with T1, threat-scene pictures were rated as significantly more threatening than threat-body pictures. However, at T2 this difference represented a slightly larger effect than at T1. Further analysis was conducted to investigate whether threat ratings differed between T1 and T2. There were no significant differences between participants who attended both time points for neutral-body (z = -1.30, p = .195) or threat-body pictures (z = -.58, p = .56). However, neutral-scene pictures (z = -2.78, p =.01, r = .23) were rated as significantly more threatening at T2 and there was also a trend for threat-scene pictures (z = -1.80, p =.07, r =.15) to be rated as more threatening at T2. These results suggest that greater familiarity with the pictures increases the perceived threat level of body-irrelevant pictures, but not body-relevant pictures.

What effect did the picture cues have on performance?

Mean tactile and visual performance (IE) in each of the picture conditions are displayed in Figure 4.3 below. Visual and tactile performance averaged across the conditions was significantly better at T2 than at T1, both differences yielded large effect sizes (visual T1 & visual T2: t = 44.43, p < .001, r = .98; tactile T1 & tactile T2: t = -39.57, p < .001, r = .98).

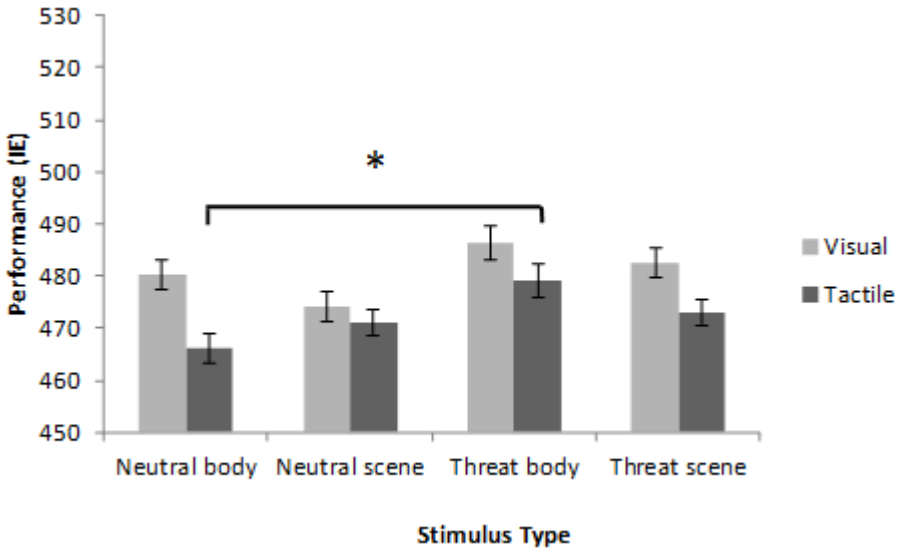

Figure 4.3 *Adjusted mean (SE) tactile and visual performance (IE) for each stimulus type.*

The analysis performed at T1 was performed at T2. There was a highly significant main effect of picture-valence (F, (1, 69) = 12.75, p = .001, η^2 = .16); with poorer performance following threatening pictures than neutral pictures (neutral mean = 474.93; threat mean = 483.14). There was also a significant effect of target-type (F, (1, 69) = 6.40, p = .01, η^2 = .09) with poorer performance for visual targets than tactile targets (tactile mean = 472.38; visual mean = 480.90). There was a near-significant effect of picture-type (F, (1, 69) = 3.15, p = .08, η^2 = .04) with poorer performance following body-relevant than irrelevant pictures (body mean = 480.89; scene mean 476.18). There were non-significant valence × picture-type (F, (1, 69) = 1.09, p = .30), valence × target-type (F, (1, 69) =.01, p >.05), and picture-type × target-type (F, (1, 69) = 1.59, p >.05) interactions. However, there was a near significant picture valence × picture-type × target-type interaction (F, (1, 69) = 3.26, p = .08, η^2 = .05). As there was a significant main effect of target-type and a near significant three way interaction follow-up ANOVAs were performed separately for tactile and visual performance.

For visual performance there was a highly significant main effect of picture-valence (F, (1, 69) = 7.45, p = .01, η^2 = .10) with poorer performance following threatening pictures than neutral pictures (neutral mean = 480.18; threatening mean = 486.78). There was also a significant main effect of picture-type (F, (1, 69), 4.69, p = .05, η^2 = .06) with poorer performance following body-relevant pictures than body-irrelevant pictures (body: 487.57; scene: 479.39). There was a non-significant picture-valence × picture-type

interaction (F, (1, 69) = .10, p > .05). This pattern of difference suggests that visual performance was better in the neutral and body-irrelevant conditions, than in the threatening and body-relevant conditions.

For tactile performance there was a significant main effect of picture-valence (F, (1, 69) = 5.23, p = .03, η^2 = .06), with poorer performance following threatening pictures than neutral pictures (neutral: mean = 469.68; threatening: mean = 477.49). There was a non-significant effect of picture-type (F, (1, 69) = .34, p > .05). There was a significant picture-valence× picture-type interaction (F, (1, 69) = 4.30, p <. 05, η^2 = .06). Follow-up tests of difference revealed that tactile performance was significantly poorer following threatening body-relevant pictures than neutral body-relevant pictures (t = -2.69, 69, p = .01, r = .31). These results suggest the main source of the significant picture-valence × picture-type interaction was the effect of threat on body-relevant pictures, which was not found for body-irrelevant pictures (neutral-scene and threat-scene: t = -.59, 69, p > .05).

4.6.3. *Discussion of primary analyses*

Threat ratings of the pictures presented in the MBT confirmed that neutral pictures were rated as significantly less threatening at both T1 and T2. These results indicate that the revised picture set was clearly recognisable within the short presentation period and that the manipulation was appropriate. At both time points there were significant differences between the perceived level of threat presented by body-relevant and irrelevant pictures in threatening and neutral conditions, however, these differences only yielded small sized effects.

There were no significant differences between participant threat ratings for body-relevant pictures at T1 and T2. However, threat ratings increased for body-irrelevant pictures at T2. This suggests that familiarity with the picture set increased participants subjective threat ratings for scene pictures but not body pictures. Although the scene pictures did not contain threatening body-relevant content, they could be interpreted as presenting a significantly greater threat to the body if participants imagined themselves in a situation that involved any of the scene pictures. For example, a house on fire (threat-scene) or a car (neutral-scene) poses greater potential body-relevant harm than a severed thumb (threat-body). It is possible that the repetition of the picture set in the task and the threat rating exercise allowed participants to think more deeply about the picture set and may explain why threat ratings for scene pictures increased at T2.

In line with the findings of the original MBT study and the pilot study (Ch. 3) visual performance was significantly poorer than tactile performance irrespective of picture condition or familiarity with the task. However, both visual and tactile performance was significantly better at T2 than T1. This improvement in performance is unlikely to be due to differences in the sample at follow-up as no significant differences in age, gender, medical conditions, physical symptom reporting, trait anxiety, anxiety or depression were found. Improvement may have been driven by practice on the visual/tactile discrimination task and/or faster disengagement from the pictures, driven by practice and greater familiarity with the picture set. The findings from the ratings, however, indicate that this change in performance was not driven by decreases in perceived threat at T2.

The picture conditions had different effects on the subsequent detection of visual and tactile targets. At T1, visual performance was poorer in both threatening conditions and the neutral body-relevant condition, than the neutral body-irrelevant condition. This suggests stronger disengagement effects for these types of pictures. At T2 the effect of the picture conditions upon the subsequent detection of visual targets was similar to that at T1, but the differences were less pronounced. Again, visual performance was poorest following threatening body-relevant pictures. However, performance following neutral body-irrelevant pictures was not significantly better than performance in the threat conditions as it had been at T1. As there were no significant differences between visual performance in threat conditions and neutral-body relevant conditions the disengagement effects observed in this study do not appear to reflect slower motor reactions in response to threat (Bradley et al., 2008). Rather it appears that changes in visual performance were based on differences in disengaging attention from the material itself.

Tactile performance was affected in a slightly different way to visual performance. At T1 presenting threatening pictures (both body-relevant and irrelevant) resulted in poorer tactile performance. Presenting neutral body-relevant pictures, however, led to better tactile performance. This suggests that viewing neutral body-relevant pictures leads to a relatively automatic shift in attention to the tactile modality, which results in facilitation for tactile targets. The visual and tactile targets in this task were presented from the same spatial location. The detection of visual targets was not facilitated following neutral body-relevant material. This suggests that the facilitation effect found for the tactile targets was not due to directing visual attention towards the hands. Indeed, presenting neutral body-relevant material resulted in a simultaneous cost for detecting visual targets and a benefit for detecting tactile targets. This suggests that presenting a picture of a neutral body part

primes attention towards the tactile modality, compared to vision. In line with the facilitation effect found at T1, tactile performance at T2 was significantly better following neutral body-relevant pictures than threatening body-relevant pictures. However, tactile performance following neutral body-relevant pictures was not significantly better than performance following neutral body-irrelevant pictures, as it had been at T1.

Research has demonstrated that presenting pictures of hands facilitates detection of subsequent tactile targets presented to the hands (Igarashi, Kimura, Spence, & Ichihara, 2008). Additionally, viewing a video image of one's own hand, whilst both hands are occluded, can also lead to facilitation for tactile targets presented to the hands (Tipper, Lloyd, Shoreland, Dancer, Howard, & McGlone, 1998). The present study, however, is the first to demonstrate that viewing neutral body-relevant pictures has differential effects on the subsequent detection of tactile and visual targets presented to the hands. Moreover, the present study also demonstrates that this effect is overridden by the effect of threat.

It is, however, not known whether all eight pictures in the neutral body-relevant condition had a similarly priming effect, or whether the effect was specifically related to the pictures of hands of which there were four. The other four pictures were: one leg/foot, one foot, one leg, and one arm. Unfortunately there is insufficient data to analyse these categories separately and determine whether they had similarly priming effects. Further research will therefore be required to investigate whether this priming effect is somatotopic. It has been observed, for example, that the effect of viewing one's own hand spreads, such that tactile acuity improves for both the hand and the cheek, but not the foot (Serino, Padiglioni, Haggard, & Làdavas, 2009). Therefore it might be expected that viewing pictures closely somatotopically related to the target location might produce a greater priming effect (e.g. pictures of the hand and face, rather than of the foot).

The findings indicate that the picture cues have different effects on the subsequent detection of tactile and visual targets. Presenting threatening-body relevant pictures results in delayed disengagement which appears to be supramodal. Interestingly, presenting neutral body-relevant material leads to facilitation for the tactile modality and a simultaneous cost for the visual modality. This suggests that presenting neutral body-relevant pictures primes the tactile modality. The improvement in performance and the less pronounced effects of the picture categories at T2 suggest that task practice and prior exposure to the pictures reduce their effect on the detection of subsequent stimuli.

4.7. Secondary analyses

4.7.1. *T1 cross-sectional analyses*

Bivariate correlations were conducted between questionnaire measures for the MBT sample (see Table 4.4 below). There was a small positive correlation between gender and health care utilisation (HCU), indicating that women had greater health care utilisation than men. There were small negative correlations between age, trait anxiety (STAI-T) and depression (BSI-D), indicating that as age increased, levels of depression and trait anxiety decreased. The presence of a medical condition (CCI) was positively associated with symptom reporting (PHQ-15), health care utilisation and health anxiety (HAI), but not with anxiety (BSI-A), depression or trait anxiety. Symptom reporting, health anxiety, trait anxiety, anxiety and depression were all significantly positively correlated with one another. Healthcare utilisation was significantly correlated with symptom reporting, health anxiety, trait anxiety and anxiety, but not depression.

Table 4.4 Bivariate correlations between T1 measures (n =104).

Measure	Gender	Age	PHQ-15	HCU	CCI	HAI	STAI-T	BSI-A	BSI-D
Gender	-	-.16	.02	.21*	.12	-.01	-.06	.11	-.12
Age		-	.12	.16	.04	-.12	-.23*	-.14	-.24*
PHQ-15			-	.41**	.35**	.50**	.45**	.49**	.45**
HCU				-	.26**	.35**	.25*	.27**	.19
CCI					-	.21*	.14	.09	-.05
HAI						-	.53*	.47**	.43**
STAI-T							-	.48**	.63**
BSI-A								-	.65**
BSI-D									-

*$p < .05$. ** $p < .001$.

Are there significant correlations between MBT performance, symptom reporting, health anxiety and health care utilisation?

Table 4.5 below displays zero-order correlations between MBT performance and sample characteristics. There were small-to-medium positive correlations between age and tactile performance in threat-body and threat-scene conditions. There were also small-to-medium positive correlations between age and visual performance in all picture conditions. These positive correlations indicate that as age increased, performance was slower for tactile targets under conditions of threat and for visual targets in all conditions.

There were small-to-moderate correlations between PHQ-15 and tactile performance in neutral-body, threat-body and threat-scene conditions and visual performance in neutral-body, neutral-scene and threat-scene conditions. There were also moderate zero-order correlations between HCU and tactile performance in all stimulus conditions. There were small- zero-order correlations between HCU and visual performance in neutral-body, threat-body and threat-scene conditions. The CCI was correlated with both tactile and visual performance in all stimulus conditions.

Table 4.5 Bivariate correlations between T1 MBT performance and questionnaire data (n = 104).

	Age	Gender	PHQ-15	HCU	CCI	HAI	STAI-T	BSI-A	BSI-D
Tactile targets									
Neutral-body	.13	.12	.21*	.25**	.22*	.03	.06	-.06	-.01
Neutral-scene	.08	.13	.19	.23**	.25*	.02	.09	-.06	-.00
Threat-body	.25*	.11	.21*	.33**	.35**	.02	.06	-.03	-.02
Threat-scene	.20*	.11	.27**	.31**	.33**	.06	.12	.01	.03
Visual targets									
Neutral-body	.39**	.08	.22*	.25*	.21**	.03	.04	.05	-.06
Neutral-scene	.24*	.08	.19*	.14	.28**	-.01	.07	-.03	.02
Threat-body	.31**	.10	.15	.25*	.23*	-.05	-.05	-.06	-.11
Threat-scene	.39**	.14	.21*	.22*	.25*	-.02	.03	-.06	-.10

*p<.05. ** p <.001.

Do these relationships remain when controlling for relevant covariates?

The positive correlations between tactile and visual performance, age, symptom reporting, health care utilisation and medical conditions suggest that poorer performance on this task is associated with these variables. The relationship between poorer task performance, symptom reporting and health care utilisation may be completely moderated by age and/or medical conditions. In order to control for the effects of age and medical conditions upon MBT performance, neutral-scene performance was included as an additional covariate in subsequent multivariate analyses of the relationship between MBT performance, symptom reporting, health anxiety and health care utilisation[4].

[4 4] Performance in the neutral scene condition was not a unique predictor of symptom reporting, health anxiety or health care utilisation when controlling for covariates see Appendix C.

Hierarchical regressions were carried out separately taking symptom reporting, health anxiety and health care utilisation as the target variables. Visual and tactile performance in neutral-body, threat-scene and threat-body conditions were taken as predictors in step 2 and with covariates (age, gender, CCI, STAI-T, BSI-A, BSI-D, and neutral-scene performance) in step 1. In addition to these covariates, health anxiety was controlled for in the analyses focusing on symptom reporting, symptom reporting was controlled for when focusing on health anxiety, and both symptom reporting and health anxiety were controlled for when focussing on health care utilisation. The same analyses were repeated at T2 and longitudinally. In each of the analyses, the regression diagnostics indicated that the assumptions of multiple-regression had been met. To aid clarity summary regression tables have been provided throughout; full details of each of the regressions can be found in Appendix C, Section C.4.

Predicting symptom reporting

None of the visual or tactile performance variables led to a significant improvement in the regression equations (see Table 4.6 below). Gender (*B range* = .39-.44, *SEB* range = .13-.14, β = .25, all *p's* < .05), medical conditions (*B range* = .36-.40, *SEB* range = .13-.14, β = .22-24, all *p's* < .05), health anxiety (*B range* = .74-.78, *SEB* range = .32-.33, β = .19-.20, all *p's* < .05), and anxiety (*B* =.04, *SEB* = .02, β = .29-.30, all *p's* < .05), were all unique predictors of symptom reporting in the final regression equations. The direction of the coefficients was positive, which indicates that being female, the presence of a medical condition, increased health anxiety and increased anxiety were associated with increased symptom reporting. The significant association between task performance and symptom reporting became non-significant when the variance in symptom reporting attributable to covariates was controlled for.

Table 4.6 Summary of hierarchical regressions predicting symptom reporting (PHQ-15), health anxiety (HAI) and health care utilisation (HCU) from MBT task performance and controlling for covariates (n = 104). Full details of regressions and covariates can be found in Appendix C, Section C.4.

	Neutral-body			Threat-scene			Threat-body		
	B	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
PHQ-15									
Visual	0.19	1.60	.021	2.07	1.64	.217	-0.04	1.46	-.01
Tactile	1.82	1.72	.21	3.10	1.74	.36.	0.67	1.52	.08
HAI									
Visual	0.40	0.49	.17	-0.07	0.51	-.03	-0.06	0.45	-.02
Tactile	0.11	0.54	.05	-0.10	0.55	-.05	-0.14	0.47	-.06
HCU									
Visual	1.40	0.87	.34	1.19	0.90	.27	2.08	0.77	.49*
Tactile	0.75	0.94	.19	1.61	0.95	.41*	1.90	0.80	.47*

*p<.05. ** p <.001.

Predicting health anxiety

None of the visual or tactile performance variables led to a significant improvement in the regression equations (see Table 4.6 above). Symptom reporting (all B = .07, all *SEB* = .03, β range = .28-.29, all p's < .05) and trait anxiety (all B = .01, all *SEB* = .00, β range = .24-.26, all p's < .05) were significant predictors in the final regression equations. The direction of the coefficients was positive which indicates that increased symptom reporting and increased trait anxiety were associated with increased health anxiety.

Predicting health care utilisation

The addition of threat-body visual performance (ΔR^2= .05, p= .01), led to a significant improvement in the regression equation see Table 4.6 above. The direction of the coefficient was positive which indicates that poorer visual performance following threatening body-relevant pictures was associated with increased health care utilisation. Furthermore, neutral-scene performance became a significant predictor (B = -.00, *SEB* = .00, β range = -.42, all p's < .05) when threat-body performance was included. The direction of the coefficient was negative which indicates that better visual performance following neutral-scene pictures was associated with increased health care utilisation. When neutral-scene performance was included as a predictor on its own the coefficient

was positive and non-significant (*B* = .01, *SEB* = .00, *β* range = .00, *p* >.05). A statistical effect such as this is known as a suppressor effect (see Section 4.7.1 for a full discussion).

The addition of threat-body tactile performance also led to a significant improvement in the regression equation (ΔR^2= .04, *p* < .05), see Table 4.6 above. The direction of the coefficient was positive which indicates that poorer tactile performance following threatening body-relevant pictures was associated with increased health care utilisation. Furthermore, neutral-scene tactile performance became a significant predictor (*B* = -.00, *SEB* = .00, *β* range = -.42, *p* < .05) when threat-body performance was included. The direction of the coefficient was negative which indicates that better tactile performance following neutral-scene pictures was associated with increased health care utilisation, again this indicates a suppressor effect (see Section 4.7.1). Threat-scene tactile performance was also a unique predictor of health care utilisation (see Table 4.6 above), however, its inclusion did not lead to a significant increase in the predictive power of the regression equation (ΔR^2= .05, *p*< .05). Gender (*B range*= .18-.19, all *SEB* = .07, *β* range = .24-.25, all *p's* < .05), age (all *B* = .01, all *SEB* = .00, *β* range = .18-.20, all *p's* < .05) and health anxiety (*B range*= .37-.43, all *SEB* = .17-.19, *β* range = .21-.25, all *p's* < .05) were all significant predictors in the final regression equations. The direction of the coefficients was positive which indicates that being female, increased age and increased health anxiety were associated with increased health care utilisation.

4.7.2. *T2: Cross sectional analysis*

Table 4.7 below displays zero-order correlations between measures. There were negative correlations between gender, trait anxiety, anxiety and depression. This suggests that men reported greater levels of psychopathology than women at time 2. Symptom reporting was significantly positively correlated with health care utilisation, health anxiety, trait anxiety, anxiety and depression. Healthcare utilisation was significantly positively correlated with health anxiety and depression. The presence of a medical condition was not significantly associated with any of the variables. Health anxiety, trait anxiety, anxiety and depression were all significantly positively correlated with one another.

Table 4.7 Zero-order correlations between, T2: demographics (age and sex), questionnaire measures: symptom reporting (PHQ-15), health care utilisation (HCU), medical comorbidity (CCI), and psychopathology (STAI-T, BSI-A, BSI-D, HAI) (n = 72).

Measure	Gender	Age	CCI	PHQ-15	HAI	HCU	STAI-T	BSI-A	BSI-D
Gender	-	-.23	-.09	-.15	-.23	.08	-.31**	-.25*	-.24*
Age		-	.12	-.09	-.02	.16	.04	.04	.15
CCI			-	.23	.13	.07	.19	.18	.13
PHQ-15				-	.62**	.34**	.57**	.58**	.54**
HAI					-	.41**	.54**	.57**	.57**
HCU						-	.20	.19	.18
STAI-T							-	.51**	.58**
BSI-A								-	.65**
BSI-D									-

*p<.05. ** p <.001.

Are there significant correlations between MBT performance, symptom reporting, health anxiety and health care utilisation?

Table 4.8 below displays zero-order correlations between measures and MBT task performance. There were small to moderate correlations between age, and performance in all picture conditions. This suggests that as age increased task performance was poorer. There was a small positive correlation between gender and visual performance in the neutral scene condition, indicating that women had poorer visual performance than men.

Table 4.8 Bivariate correlations between questionnaires and tactile targets in the four stimulus conditions (n = 70).

	Gender	Age	CCI	PHQ-15	HAI	HCU	STAI-T	BSI-A	BSI-D
Visual targets									
Neutral-body	.08	.33**	.11	.02	.16	.12	.15	.05	.09
Neutral-scene	.25*	.20	.11	.02	.12	.10	.15	-.02	-.01
Threat-body	.11	.35**	.17	-.02	.13	.15	.13	.03	.08
Threat-scene	.06	.35**	.12	.06	.16	.13	.17	.12	.11
Tactile targets									
Neutral-body	.16	.21	.15	.17	.22	.16	.23	.09	.05
Neutral-scene	.11	.22	.17	.13	.19	.17	.21	.07	.01
Threat-body	.15	.26*	.15	.10	.13	.23	.14	.05	.03
Threat-scene	.12	.22	.21	.14	.19	.21	.21	.08	.03

*p<.05. ** p <.001.

Do these relationships remain when controlling for relevant covariates?

The multivariate analysis conducted at T1 was repeated at T2.

Predicting symptom reporting

None of the visual or tactile performance variables led to a significant improvement in the regression equation (see Table 4.9 below). Health anxiety (*B range* = .27-.29, *all SEB* = .11, *β range* = .27-.29, all *p's* < .05), trait anxiety (all *B* = .02, *all SEB* = .01, *β* = .25-.26, all *p's* < .05), and anxiety (all *B* =.04, *all SEB* = .03, *β* = .24-.25, all *p's* < .05) were all unique predictors of symptom reporting in the final regression equations. The direction of the coefficients was positive which indicates that increased health anxiety, trait anxiety and current anxiety were associated with increased symptom reporting.

Table 4.9 Summary of hierarchical regressions predicting symptom reporting (PHQ-15), health anxiety (HAI) and health care utilisation (HCU) from MBT task performance and controlling for covariates (n = 70). Full details of regressions and covariates can be found in Appendix C, Section C.4.

	Neutral-body			Threat-scene			Threat-body		
	B	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
PHQ-15									
Visual	0.09	2.22	.01	-0.63	2.64	-.06	-1.54	2.37	-.15
Tactile	0.86	3.01	.09	0.49	2.79	.05	1.85	2.19	.19
HAI									
Visual	3.82	2.39	.35	-0.98	2.97	-.08	3.35	2.60	.30
Tactile	0.39	3.34	.04	-2.09	3.10	-.20	-1.64	2.44	-.15
HCU									
Visual	-0.01	1.43	-0.00	-0.45	1.71	-.08	1.16	1.53	.23
Tactile	-0.84	1.92	-0.18	2.17	1.76	.47	2.41	1.38	.51

*p<.05. ** p <.001.

Predicting health anxiety

None of the visual or tactile performance variables led to a significant improvement in the regression equation (see summary Table 4.9 above). Symptom reporting (all B = .29-.32, all SEB = .14, β range = .26-.28, all p's < .05) was a significant predictor in the final regression equations. The direction of the coefficient was positive which indicates that increased symptom reporting was associated with increased health anxiety.

Predicting health care utilisation

None of the visual performance variables led to a significant improvement in the regression equation. The addition of threat-body tactile performance, led to a near significant improvement in the regression equation (ΔR^2= .04, p = .09**)**. The direction of the coefficient was positive which indicates that poorer tactile performance following threatening body-relevant pictures was associated with increased health care utilisation. Both age (all B = .01, all SEB = .01, β range = .22-27, all p's < .05) and health anxiety (B *range*= .14-.16, all SEB =.06-.07, β range = .29-.37, all p's < .05) were significant predictors in the final regression equations. The direction of the coefficients was positive

which indicates that increased age and health anxiety were associated with increased health care utilisation.

4.7.3. *Longitudinal analyses*

Table 4.10 below presents zero-order correlations between T1 and T2 self-report variables. All T1 measures were highly correlated with their T2 counterpart. This suggests that levels of symptom reporting, health care utilisation, medical conditions, health anxiety, trait anxiety, anxiety and depression were relatively stable over the six month period. Gender was negatively associated with trait anxiety and depression, which indicates that men had higher levels of trait anxiety and depression. Age was positively associated with health care utilisation, which indicates that older participants had higher health care utilisation. Symptom reporting was positively correlated with health care utilisation, the presence of a medical condition, health anxiety, trait anxiety, anxiety and depression. Health care utilisation was positively associated with the presence of a medical condition, health anxiety and trait anxiety, anxiety and depression. Trait anxiety, anxiety and depression were all highly correlated with one another.

Table 4.10 Zero-order correlations between, T1 and T2: demographics (age and gender) and questionnaire measures: symptom reporting (PHQ-15), health care utilisation (HCU), medical conditions (CCI), and psychopathology (HAI; STAI-T; BSI-A; BSI-D) (n = 70).

Measure	Gender	Age	CCI	PHQ-15	HCU	HAI	STAI-T	BSI-A	BSI-D
Gender	1.00	-.23	-.01	-.01	.16	-.19	-.30*	-.22	-.28*
Age		1.00	.16	-.02	.30*	.06	.03	.21	.02
CCI			.90**	.41**	.18	.25*	.29*	.04	.04
PHQ-15				.69**	.35**	.47**	.44**	.39**	.42**
HCU					.74**	.29*	.15	.22	.27*
HAI						.84**	.51**	.43**	.46**
STAI-T							.81**	.54**	.55**
BSI-A								.54**	.59**
BSI-D									.68**

*p<.05. ** p <.001.

Are there significant correlations between MBT performance, symptom reporting, health anxiety and health care utilisation?

Table 4.11 below displays zero-order correlations between T1 MBT performance and T2 demographics and self-report measures. There were small-medium sized correlations between task performance and age, the presence of a medical condition and health care utilisation.

Table 4.11 Bivariate analysis between T1: tactile and visual targets in the four stimulus conditions and T2: questionnaires (n = 70).

	Gender	Age	CCI	PHQ-15	HCU	HAI	STAI-T	BSI-A	BSI-D
Visual Targets				.					
Neutral-body	.07	.39**	.21	-.00	.15	.06	.16	.12	-.07
Neutral-scene	.07	.24*	.30**	.02	.10	.06	.12	.18	.01
Threat-body	.12	.31**	.24*	-.03	.19	-.01	.01	.09	-.09
Threat-scene	.14	.37**	.23	-.00	.15	.03	.08	.10	-.09
Tactile Targets									
Neutral-body	.08	.13	.26*	.11	.22	.16	.12	.10	-.12
Neutral-scene	.13	.09	.25*	.14	.21	.10	.11	.08	-.15
Threat-body	.05	.25**	.25*	.11	.24*	.10	.12	.09	-.06
Threat-scene	.06	.20*	.26*	.13	.23*	.13	.13	.15	-.01

*p<.05. ** p <.001.

Do these relationships remain when controlling for relevant covariates?

The analyses conducted at both T1 and T2 were repeated. In order to investigate clues to causality, T1 MBT performance variables were taken as predictors, T2 symptom reporting, health anxiety and health care utilisation were taken as the target variables, and T1 symptom reporting, health anxiety and health care utilisation as well as the covariates in the cross-sectional analyses were controlled for (e.g., when predicting T2 symptom reporting, we controlled for T1 symptom reporting, age, gender, medical conditions, health anxiety, trait and state anxiety and depression.)

Predicting symptom reporting

None of the visual or tactile performance variables led to a significant improvement in the regression equation (see summary table 4.12 below). Symptom reporting (*B range=*

.70-.72, *SEB* = .13 & .14, *β* range = .63-.65, all *p's* < .001) was a significant predictor in the final regression equations. The direction of the coefficient was positive which indicates that increased T1 symptom reporting was a predictor of increased T2 symptom reporting.

Table 4.12 Summary of hierarchical regressions predicting T2: symptom reporting (PHQ-15), health anxiety (HAI) and health care utilisation (HCU) from T1: MBT task performance and controlling for T1: covariates (n = 70). Full details of regressions and covariates can be found in Appendix C, Section C.5.

	Neutral-body			Threat-body			Threat-scene		
	B	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
PHQ-15									
Visual	0.37	2.06	.04	1.98	2.00	.21	1.37	2.22	.14
Tactile	-0.33	2.52	-.04	2.61	1.79	.29	-1.44	2.49	-.16
HAI									
Visual	-1.13	1.80	-.10	-0.71	1.76	-.07	-0.18	1.95	-.02
Tactile	-0.79	2.21	-.08	1.67	1.58	.16	1.72	2.18	.17
HCU									
Visual	-1.15	0.96	.16	0.71	0.97	.15	0.08	1.04	.02
Tactile	-0.56	1.16	.03	-0.01	0.85	-.00	-1.07	1.16	-.25

*p<.05. ** p <.001.

Predicting health anxiety

None of the visual or tactile performance variables led to a significant improvement in the regression equation (see summary table 4.12 above). T1 health anxiety (*B range*= 3.47-.49, *SEB* = 0.38 & 0.49, *β* = .76 &.77, all *p's* < .001) was a significant predictor in the final regression equations. The direction of the coefficient was positive which indicates that increased T1 health anxiety was a predictor of increased T2 health anxiety.

Predicting health care utilisation

None of the visual or tactile performance variables led to a significant improvement in the regression equations (see summary table 4.12 above). T1: health care utilisation (*B*

range= 0.88-0.94, *SEB* = 0.11 & 0.12, β = .78-.84, all *p's* < .001), trait anxiety (All *Bs* = -0.01, All *SEB* = 0.00, β *range* = -.23- -.27, all *p's* < .05), and depression (All *Bs* = 0.03, all *SEB* = 0.01, β = .43-.47, all *p's* < .05), were significant predictors in the final regression equations. The direction of the coefficients for health care utilisation and depression were positive, which indicates that increased T1 health care utilisation and depression were predictors of increased T2 health care utilisation. The direction of the coefficient for trait anxiety was negative, which indicates that decreased trait anxiety is a predictor of increased health care utilisation.

The significant cross-sectional relationship found at T1 between better performance following neutral body-irrelevant pictures and poorer performance following threatening body-relevant pictures and increased health care utilisation was not found longitudinally when controlling for T1 covariates. This suggests that significant disengagement effects may be a consequence of healthcare utilisation rather than a cause of health care utilisation, or that their maybe a third variable that is responsible for both disengagement effects and healthcare utilisation. In order to investigate the former hypothesis we investigated whether T1 healthcare utilisation predicts T2 MBT performance when controlling for T1 MBT performance.

Predicting MBT performance

T1 health care utilisation did not lead to a significant improvement in the regression equations (see summary table 4.14 below). T1 tactile and visual MBT performance (*B range*= 0.52-0.71, *SEB range* = 0.07-0.11, β = .54-.77, all *p's* < .001) were significant positive predictors of T2 tactile and visual MBT performance in the final regression equations.

Table 4.13 *Summary of hierarchical regressions predicting T2: neutral and threatening body-relevant and irrelevant tactile and visual performance from T1: health care utilisation (HCU) and controlling for covariates (n = 70). Full details of regressions and covariates can be found in Appendix C, Section C.5.*

	Neutral-scene			Neutral-body			Threat-scene			Threat-body		
	B	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
<u>*HCU*</u>												
Visual	-0.00	0.03	-.02	-0.03	0.03	-.12	-0.02	.03	-.07	-0.03	0.02	-.13
Tactile	-0.02	0.02	-.06	-0.02	0.02	-.07	0.00	0.03	.01	-0.03	0.02	-.11

*p<.05. ** p <.001.

These results do not support the hypothesis that the cross-sectional relationship observed between MBT performance in neutral and threatening body-relevant conditions and health care utilisation is a consequence of health care utilisation. These results suggest that there may be a third unaccounted for variable that is responsible for both disengagement effects and health care utilisation.

4.7.4. *Discussion of secondary analyses*

At T1 poorer task performance was positively correlated with age, the presence of a medical condition, physical symptom reporting and health care utilisation. At T2 poorer task performance was positively correlated with age, but not symptom reporting, health anxiety or health care utilisation. Furthermore, at T2, poorer visual performance in the neutral body-irrelevant condition was correlated with being female. As previously discussed in Chapter 3, women typically have slower RTs than men and it is likely that at T2 when the effects of the picture cues were reduced the simpler neutral body-irrelevant condition allowed this association to be detected. These findings suggest that the relationship between poorer performance on the MBT, symptom reporting and health care utilisation may in part be due to organic factors such as age, gender and the presence of a medical condition, rather than specifically related to attentional effects. Thus, in order to control for the effect of organic factors on task performance, target performance in the neutral body-irrelevant condition was included as a covariate in subsequent multivariate analyses.

When relevant covariates were controlled for, tactile and visual performance in each of the picture conditions at both T1 and T2 were not significant predictors of symptom reporting or health anxiety. However, T1 tactile performance in the threatening body-irrelevant condition was a near significant positive predictor of symptom reporting. This provides some evidence that high symptom reporters may have greater difficulties disengaging from threatening body-irrelevant pictures. At both time points being female, the presence of a medical condition and increased health anxiety were independently associated with increased symptom reporting. Both symptom reporting and trait anxiety had independent positive associations with health anxiety. These findings are consistent with epidemiological research that has found these factors to be strongly associated with one another (Barsky et al., 2001; Barsky et al., 2005; Crombez, Beirens, Van Damme, Eccleston, & Fontaine, 2009; Creed & Barsky, 2004; Pennebaker, 1982; Watson & Pennebaker, 1989).

When relevant covariates were controlled for at T1, better performance following neutral body-irrelevant pictures and poorer performance following threatening body-relevant pictures were independently associated with increased health care utilisation, irrespective of target modality. At T2, a trend was observed for the same pattern but only for the tactile modality. This suggests that increased health care utilisation is associated with enhanced disengagement from neutral body-irrelevant pictures and delayed disengagement from threatening body-relevant pictures. In addition, being female, increased age, symptom reporting and health anxiety were independently associated with increased health care utilisation.

As previously discussed in the primary analysis, task familiarity had an impact on overall performance on the MBT, such that there was an improvement in both visual and tactile performance at T2. The lack of a significant cross-sectional relationship between visual performance and health care utilisation at T2 may therefore be due to greater familiarity with the task. Familiarity with the task may reduce the attention paid to the picture stimuli and their impact on the detection of visual targets. The near significant relationship between tactile performance and health care utilisation at T2 suggests that the effects of presenting pictures cues of this type, on attention to touch and therefore the body, may be more enduring. The subjective threat ratings of the body-relevant pictures did not differ significantly between T1 and T2 which suggests that familiarity did not reduce the perceived level of threat elicited by the pictures.

Interestingly, throughout the multivariate analyses, entering performance following neutral pictures and performance following threatening body-relevant pictures simultaneously, improved the predictive power of both variables, as well as the predictive power of the regression equation; this type of effect is known as 'suppression'. The most commonly accepted definition of a suppressor variable is that proposed by Conger (1974, pp. 36-37) "a variable which increases the predictive validity of another variable (or set of variables) by its inclusion in a regression equation". In addition, including both variables led to neutral body-irrelevant performance becoming a negative predictor while threatening body-relevant performance remained a positive predictor. If the predictive power of two variables is simultaneously improved when they are both included in a regression equation and the beta coefficient of one variable becomes negative and the other positive, the effect is known as "negative suppression" (Tzelnik & Henik, 1991). Following the work of Velicer (1978), predictor variance can be divided into two portions: that is variance which is shared with the outcome variable (in this case health care utilisation), known as valid variance, and variance which is independent of the outcome variable, known as error. A second predictor may contribute to the regression directly by explaining valid variance. However, a second predictor may also contribute to the regression by indirectly accounting for error in the first predictor, in which case the second predictor functions as a suppressor. Suppressors contribute to the regression by removing error and enhancing the ability of predictors to explain variance in the outcome variable (Smith, Ager, & Williams, 1992). Performance following neutral material was entered into the regression analyses in order to control for general task performance. Therefore it is unsurprising that including both performance following neutral material and performance following threatening body-relevant material should result in negative suppression. It appears that the inclusion of both performance variables cancels-out error variance associated with general task performance and this unmasks valid variance in both variables which is associated with health care utilisation (Mackinnon, Krull, & Lockwood, 2000).

Both visual and tactile targets were presented from similar spatial locations, consequently attending to visual targets also involved attending to the same spatial location as the body (hands e.g. peripersonal space; for a review see Holmes & Spence, 2004). The detection of both types of target could therefore be considered to provide a measure of attention to the body. Thus faster responses to both visual and tactile targets in the neutral body-irrelevant condition could be interpreted as a tendency to focus on, or hypervigilance for, the body under neutral conditions. Whilst under conditions of body-relevant threat,

delayed disengagement effects were observed in both modalities, which suggest that body-relevant threat captures attention more strongly.

Whilst it is agreed that anxiety states are characterised by attentional biases towards threat, there is not yet a clear consensus on whether such attentional biases consist of hypervigilance for threat, delayed disengagement from threat or both (Cisler, Bacon & Williams, 2009; Cisler & Koster, 2010; Fox Russo, & Dutton, 2002). Even less empirical evidence exists regarding the nature of the attentional biases hypothesised to operate in health anxiety and symptom reporting. Theories of both MUS and health anxiety generally propose a hypervigilance for the body (Pennebaker, 1982; Barsky & Wyshak, 1990; Rief & Barsky, 2005; Brown, 2004, Deary et al., 2007). However, most would also propose a hypervigilance for the body particularly in response to threat (Pennebaker, 1982; Barsky & Wyshak, 1990; Rief & Barsky, 2005; Deary et al., 2007).

A recent study by Jasper and Witthöft (2011) has demonstrated that both hypervigilance for, and delayed disengagement from, illness related pictures is associated with health anxiety. However, the relationship observed in the present study between disengagement effects and health care utilisation was independent of health anxiety, trait anxiety and state anxiety. This suggests that similar processes to those observed in anxiety states may operate for those who are high health care utilisers, but that anxiety states do not account for this relationship.

The lack of a significant cross-sectional relationship between disengagement effects and symptom reporting or health anxiety (when controlling for covariates) was unexpected, and seems counterintuitive given previous findings (Roelofs et al., 2003; Rief & Auer, 2001; Hou, Moss-Morriss, & Bradley, 2008; Brown, Poliakoff & Kirkman, 2007; Brown et al., 2010) and the significant association observed here between disengagement effects and health care utilisation. Theories of both MUS and health anxiety would suggest attention to the body increases the perception or misperception of bodily symptoms and it is assumed that the perception of symptoms and anxiety about those symptoms stimulate health seeking behaviours. However, when the effects of health anxiety and symptom reporting were controlled for, the significant relationship between attentional disengagement and health care utilisation remained. Although health anxiety was not associated with task performance, symptom reporting and task performance were correlated at T1, but, when controlling for covariates, they were no longer significantly associated with one another. This may reflect that, once the covariates were controlled for, there was very little variance left in symptom reporting for task performance to explain.

However, there were non-significant correlations between T2 task performance and symptom reporting and T1 task performance and T2 symptom reporting. This suggests that there was not a significant relationship between disengagement effects and symptom reporting, irrespective of controlling for covariates. Levels of symptom reporting were relatively stable between T1 and T2, therefore, changes in symptom reporting do not account for the non-significant cross-sectional or longitudinal associations.

The measures of symptom reporting, health anxiety and health care utilisation are subject to multiple sources of variance such as acute and chronic illness, psychopathology and reporting biases. Both the symptom reporting measure and the health anxiety measure may lack sensitivity for discriminating between those who are bothered by symptoms or anxious about their health and those who are bothered enough by symptoms or anxiety about their health to seek health care. In contrast, health care utilisation captures precisely those who are bothered enough by symptoms or anxiety about their health to seek health care. Arguably then, health care utilisation provides a purer measure of physical symptoms and health concerns which are bothersome enough to produce health care behaviour.

Jasper and Witthöft (2011) found that delayed disengagement from illness-related pictures was associated with the behavioural (i.e. reassurance seeking) and perceptual components but not the cognitive components of the multidimensional inventory of hypochondriachal traits (MIHT; Longley et al., 2005). In the present study, the HAI was used to assess health anxiety and this measure assesses a mixture of cognitive and perceptual factors, it does not however address behavioural factors. Taken together, the cross-sectional results of the present study and those of Jasper and Witthöft (2011) suggest that disengagement effects may be more strongly associated with behavioural factors such as health care utilisation. Furthermore a recent randomised controlled pilot study of attention training for health anxiety found that reducing body-focused attention led to reductions in health anxiety. However, reducing body-focused attention was not a necessary component for reducing health anxiety. Similar reductions were achieved without using attention training (Weck, Neng & Stangier, 2013). This study did not measure health care utilisation, it is possible that reducing attention to the body may have reduced health care utilisation. Attentional effects may not be causal factors in the development of symptoms or health anxiety but may be considered to exacerbate or maintain physical symptoms or health anxiety, via health care utilisation.

The cross-sectional results indicate that both faster disengagement from neutral body-irrelevant material and delayed disengagement from threatening body-relevant material are independently associated with health care utilisation.

However, the results of the longitudinal analysis revealed that when controlling for covariates, none of the MBT performance variables predicted T2 symptom reporting, health anxiety or health care utilisation. Nor did T1 health care utilisation predict T2 MBT performance when controlling for T1 MBT performance and T1 covariates. These results suggest that there may not be a causal relationship between attentional disengagement and health care utilisation, in either direction. It is possible that the variable or variables responsible for the cross-sectional relationship between disengagement effects and health care utilisation have been measured in the present study but that measurement error has obscured this relationship. The measures of symptom reporting, state, trait and health anxiety and depression all demonstrated good reliability. However, the presence of an organic medical condition was controlled for using the CCI, which measures the presence of 12 common chronic conditions. Thus participants may have had organic conditions which affected both health care utilisation and attentional disengagement that were not controlled for in the analyses. It should be noted, however, that the participants age range was 18-50 yrs, and the average age was 30.11 yrs thus they would be unlikely to be suffering from age related health conditions. Furthermore, age was used as a covariate throughout these analyses.

It is also possible that a third unaccounted for variable is responsible for hypervigilance, delayed disengagement and increased health care utilisation. Traumatic experiences, for example, have been shown to have significant relationships with MUS and health care utilisation (e.g. Katon, Sullivan, & Walker, 2001; Fiddler, Jackson, Kapur, Wells, & Creed, 2004; Kotsopoulos et al., 2005). Furthermore, post-traumatic stress disorder (PTSD) has particularly strong associations with attentional biases for threat (McNally, 1996). However, trauma is also strongly associated with physical symptom reporting and health anxiety (e.g. Stein et al., 2004). It is therefore unclear why health care utilisation, but not health anxiety or symptom reporting should be associated with attentional effects if the source of the association is trauma. As suggested previously this could be because health care utilisation provides a purer measure of physical symptoms and health concerns which are bothersome enough to produce health care behaviour.

The theories of symptom perception, MUS and health anxiety discussed in Chapter one hypothesise that attentional abnormalities are central to the development and

maintenance of physical symptoms. The results of this study do not support the hypothesis that attentional biases are central do the development of physical symptoms or health anxiety, nor do they support the more specific predictions made by dissociative, biopsychosocial, cognitive-attentional and neurobiological models.

Dissociative models propose more general attentional deficits, which affect the integration of all types of sensory information with conscious awareness (Janet, 1907; Khilstrom, 1992). In line with this hypothesis we might expect a general problem disengaging attention to be associated with physical symptom reporting, which was not supported here. Biopsychosocial models propose a general body-focused attentional bias and specific biases for illness-related information (Pennebaker, 1982; Barsky, & Wyshak, 1990; Cioffi, 1991; Rief & Barsky, 2005). Later cognitive-attentional (Brown, 2004) and neurobiological models (Edwards et al., 2012) have implicated attentional biases specifically for symptom representations or abnormal illness beliefs, rather than attention to the body per se. If this was the case, we would expect hypervigilance for the body under neutral conditions and/or delayed disengagement from body-relevant threat to be associated with symptom reporting or health anxiety, which again was not supported here.

These results suggest that biases in attentional disengagement do not play a significant role in the development of physical symptoms or health anxiety. However, these results are in contrast to previous cross-sectional research that has found MUS to be associated with difficulties disengaging visual attention from neutral stimuli (Roelofs et al., 2003; Rief & Auer, 2001) and threatening stimuli (Hou, Moss-Morriss, & Bradley, 2008). Whilst health anxiety has been associated with both hypervigilance for, and delayed disengagement from, symptom relevant material in the visual modality (Jasper & Witthöft, 2011).

In this study we used attentional disengagement from visual stimuli as a proxy measure of both attention to the body and biases for symptom relevant material. However, a body-focused attentional bias could mean that attention is orientated more readily to bodily sensations, or that touch receives priority processing over other sensory modalities or that there are difficulties disengaging specifically from touch. It is therefore possible that a body-focused bias is associated with symptom reporting and/or health anxiety via attentional processes not measured in the present research. Interestingly, a previous study by Brown et al., (2010) found that, following a neutral film, high symptom reporters displayed delayed disengagement from tactile cues compared to low symptom reporters. Following a trauma film, however, high symptom reporters displayed avoidance of the

tactile cues. Thus it is possible that measuring the effect of visual stimuli on disengagement in the visual and tactile modality does not directly capture body-focused attentional processes.

4.7.5. *Strengths, limitations and future directions*

The main strengths of this study are its prospective design, its use of an objective measure of attention and its application to a large sample of patients recruited from primary care.

A bespoke self-report questionnaire was employed to measure health care utilisation, rather than employing an existing questionnaire from health economics. Existing measures record information about health care utilisation in order to estimate costs. The type of information collected reflects the research question and the perspective taken. For example, studies are typically interested in the cost of patients' health care utilisation to the NHS; consequently they take an NHS perspective and focus on the use of NHS services. The present study was concerned with individual differences in attention and somatic awareness and their relationship with individual differences in symptom reporting, health anxiety and health care utilisation. We therefore wished to capture information about individual differences in health care utilisation from the perspective of the patient. This entailed collecting information on health care utilisation across a broad range of settings, not just those provided by the NHS. Using a bespoke measure allowed us to collect a broad range of information about health care utilisation, from the perspective of the patient. This allowed us to take a more holistic view of health care utilisation, however, there are difficulties with such an approach.

Using a bespoke measure means that there is no evidence other than that reported in the present study to support the measures validity and reliability. It is also difficult to draw comparisons with other research using standardised measures (Boynton & Greenhalgh, 2004). Although as Ridyard, Dyfrig, & Hughes (2010) have noted, even among health technology assessment funded trials, which typically take either an NHS perspective or a societal perspective, the type of measures used to investigate health care utilisation are highly variable. Furthermore, taking a patient perspective, although directly relevant to the aims of this research, makes it difficult to draw comparisons with research taking a NHS perspective or a much broader societal perspective. However, these difficulties are not limited to the present study, they are difficulties found in the field of health economics in

general. As a result, a recent Medical Research Council funded project has been set up to compile a Database of Instruments for Resource Use Measurement (DIRUM) in order to promote standardisation and best practice across research. Unfortunately there was not a suitable instrument available from DIRUM for the purposes of this study.

In summary, this study sheds new light on the relationships between attention, symptom reporting, health anxiety and health care utilisation. Using the MBT, it was found that health care utilisation, but not symptom reporting or health anxiety, was associated with hypervigilance for the body following neutral body-irrelevant pictures and delayed disengagement following threatening body-relevant pictures. These relationships were independent of age, gender, medical conditions, symptom reporting, health anxiety, trait anxiety, state anxiety and depression. This suggests that the relationship between disengagement effects and health care utilisation is independent of organic factors and psychopathology. These findings were unexpected, as they are counter to previous findings that delayed disengagement is associated with both symptom reporting and health anxiety.

The longitudinal results, however, do not support theories of either MUS or health anxiety, which suggest that attention to the body is a causative factor in the development of physical symptoms, health anxiety or health care utilisation (e.g. Brown, 2004, Edwards et al., 2012; Pennebaker, 1982; Barsky & Wyshak, 1990; Rief & Barsky, 2005; Deary et al., 2007) . Health care utilisation is considered an important maintaining factor for both MUS and health anxiety in cognitive behavioural models of MUS (e.g. Deary et al., 2007). These results tentatively suggest that reducing attention to the body and improving disengagement from threatening symptom relevant material may indirectly reduce reassurance seeking behaviour (health care utilisation) and vice versa, via a third unknown variable.

Future research, should incorporate an improved measure of organic conditions (see Chapter 6 for further discussion of this), to investigate the relationship between disengagement effects and increased health care utilisation. In order to investigate whether a general body-focused bias and/or a specific bias for threatening body-relevant material are causative factors in the development of physical symptoms, health anxiety and health care utilisation, research into other hypothesised attentional processes is necessary (e.g., investigating whether touch receives priority processing over other sensory modalities, see Chapter 8 for further discussion of this).

Chapter 5. Somatic awareness, symptom reporting, health anxiety, and health care utilisation.

5.1. Introduction

This chapter presents and discusses the SSDT findings from the primary care study outlined in the previous chapter; the relationship between SSDT and MBT variables is also explored. As the results of the SSDT are discussed in this chapter, evidence regarding the relationship between somatic awareness, symptom reporting and health anxiety is described briefly below.

5.1.1. *Somatic awareness, symptom reporting and health anxiety*

Symptom reporting and health anxiety are highly related constructs (Creed & Barsky, 2004). Psychological models suggest that high-symptom reporters and highly health anxious individuals are more likely to perceive benign physical sensations, to attribute them as symptoms, and to seek medical help (Pennebaker, 1982; Barsky & Wyshak, 1990; Rief & Barsky, 2005). Both somatosensory amplification (Barsky & Wyshak, 1990), and decreased filtering (Rief & Barsky, 2005; Cioffi, 1990), have been hypothesised as possible mechanisms for the increased perception of physical sensations in somatic awareness. A study by Katzer et al., (2011), found that symptom reporting in a student sample was not associated with an enhanced ability to detect subtle tactile sensations (i.e. lower tactile thresholds). In a later study by the same research group, it was found that patients with SFD had lower tactile thresholds than healthy controls (Katzer et al., 2012). This suggests that somatic awareness in clinical high symptom reporters may be altered and supports the idea that processes such as somatosensory amplification and decreased filtering may be responsible for increased symptom reporting. Further research is required to investigate whether this is a reliable finding and whether tactile threshold may also be related to health anxiety and health care utilisation. As studies investigating associations between tactile threshold and symptom reporting have been cross-sectional in nature, causal relationships have not yet been established. It is possible that decreased tactile threshold is a consequence rather than a cause of symptom reporting.

Whilst somatosensory amplification and decreased filtering may account for more general unexplained symptoms, such as, fatigue and pain, as we saw in Chapter 1, it is unclear how such processes account for MUS, such as, non-epileptic seizures or

conversion paralysis (Brown, 2004). Both types of MUS are likely to be explained by common processes (Brown, 2004; Edwards et al., 2012). Brown's model suggests that many MUS are actually distortions in somatic awareness, brought about by, the over-activation of symptom representations stored in the cognitive system. Individual differences in the tendency to experience distortions in somatic awareness may, therefore, be considered a risk factor for symptom reporting. The model suggests that this trait like characteristic may interact with other factors, such as, attention and emotional state, to activate symptom representations that are then experienced as current percepts. Thus the model is able to account for symptoms in the absence of peripheral sensation or the anxious misinterpretation of sensations, such as functional neurological symptoms.

There is a growing body of evidence suggesting that symptom reporting is associated with a tendency to experience distortions in somatic awareness (i.e. false alarms on the SSDT; Brown et al., 2010; Brown et al., 2012; Katzer et al., 2011; Katzer et al., 2012). More recently, the tendency to experience distortions in somatic awareness has also been associated with health anxiety in a student population (Katzer et al., 2011). However, the causal relationship between somatic distortion, symptom reporting and health anxiety has not yet been established. It is possible that somatic distortion is a consequence rather than a cause of symptom reporting and health anxiety. Furthermore it is unknown whether somatic distortion is also predictive of health care utilisation.

In Chapter 3, the relationship between somatic awareness and attention was investigated, with the correlations between tactile threshold, symptom reporting and health anxiety all being non-significant. However, there were near significant negative relationships between visual attentional disengagement and the tendency to experience somatic distortions. That is, difficulty disengaging visual attention from picture cues was associated with a reduced tendency to experience somatic distortions. The Brown model suggests that delayed disengagement from symptom relevant material, and a greater tendency to experience distortions in somatic awareness, may be associated with symptom reporting. However, the model makes no claims about the relationship between delayed disengagement and somatic distortion. This finding suggests that the two processes may be related to one another in non-clinical symptom reporters, which warrants further investigation.

5.2. Study aims and research hypotheses

The first aim of the present chapter was to confirm the reliability and validity of the SSDT as it was used here. This required establishing whether (i) the revised thresholding procedure on the SSDT yielded thresholds within the expected range for at least 80% of participants; (ii) the revised SSDT thresholding procedure yielded thresholds with adequate test-retest reliability; and (iii) participants' performance on the task was consistent with previous research (e.g. that there is a significant effect of the light and a non-significant effect of block).

The models of both Rief and Barsky (2005) and Cioffi (1991) would predict that high symptom reporters and those who are highly health anxious have lower thresholds for detecting somatosensory stimuli (i.e., a deficit in selection). The models of Cioffi (1991), Brown (2004), Rief and Barsky (2005), Barsky and Wyshak (1990) and Warwick and Salkovkis (1990) all propose that specific biases in selective attention influence the contents, or interpretation of the contents, of somatic awareness. These models would all therefore predict that a tendency to experience distortions in somatic awareness (i.e., false alarms on the SSDT) would be associated with symptom reporting and health anxiety. We also wished to investigate whether threshold and false alarms on the SSDT were associated with health care utilisation.

The second aim was therefore to investigate whether somatic awareness (i.e. SSDT performance: tactile threshold & false alarm rate) is associated with symptom reporting, health anxiety and health care utilisation cross-sectionally, longitudinally and independently of other relevant covariates. This part of the analysis tested the following hypotheses: (i) that there would be significant negative correlations between tactile threshold on the SSDT, symptom reporting, health anxiety, and health care utilisation; (ii) that there would be a significant positive correlation between somatic distortion (false alarm rate) on the SSDT, symptom reporting, health anxiety and health care utilisation, and that these relationships would be significant (a) cross sectionally; (b) longitudinally; and (c) would remain after controlling for relevant covariates (e.g. age, gender, medical conditions, trait anxiety, state anxiety and depression).

We also had the exploratory aim of investigating whether tactile threshold, somatic distortions and attentional disengagement (visual & tactile performance on the MBT) are associated with one another.

5.3. Method

See Chapter 4 for details of the method and a full description of the sample.

5.4. Statistical analysis

5.4.1. *Data preparation*

At T1 data from all 109 participants who took part in the study were included in the final SSDT sample; however, one participant did not complete the Brief Symptoms Inventory (BSI) because they felt unwell. Therefore in correlational and hierarchical analysis involving the anxiety (BSI-A) and depression (BSI-D) subscales of the BSI, data from 108 participants were included in the final sample. At T2, 72 participants returned for follow-up, of whom two did not complete the task (1 because they were unwell, and 1 because of time constraints); 70 participants were therefore included in the final T2 SSDT sample.

Prior to analysis, data from the SSDT were prepared according to the procedure outlined in Chapter 3, Section 3.4.1.

5.4.2. *Data distribution*

Both questionnaire and task data were screened for normality. Non-normal variables (see Appendix D, Section D.1 for full details) were transformed using log and square root transformations as appropriate, following the recommendations of Tabachnick and Fiddell (1996). The following variables were non-normal and were unable to be transformed: T1: age; gender; CCI; BSI-A; BSI-D; Pre SSDT tactile threshold, average tactile threshold (pre- & post- threshold averaged); hit rates and FA rates in block 1 and 2 in both conditions; FA change in both light-conditions; T2: age; gender; CCI; BSI-A; BSI-D; hit rates and FA rates in blocks 1 and 2 in both light conditions; FA change in both light conditions). Therefore non-parametric tests were used in the analysis of these variables.

5.4.3. *Analyses addressing study aims and hypotheses*

Preliminary analysis. To establish the validity and reliability of the computerised threshold procedure the following analyses were performed at T1 and T2: (i) to determine the temporal stability of the threshold, test-retest correlations and tests of difference were

conducted between the pre- and post-experimental threshold measurements; (ii) to determine the validity of the threshold procedure, Block 1 light-absent hit rates were screened to establish whether participant performance was in the 40-60% range expected; (iii) to establish whether SSDT performance was comparable to previous studies, tests of difference were conducted between block 1 and 2 and between light conditions for: hit rate, false alarm rate, response criterion (*c*) and tactile sensitivity (*d*').

Evaluation of the study hypotheses. The main SSDT analyses were conducted cross-sectionally at both time points and longitudinally (where T1 tactile threshold and false alarm variables were the predictors and T2 symptom reporting, health anxiety and healthcare utilisation were the target variables). Correlations were used to investigate the relationships between SSDT performance, symptom reporting, health anxiety and health care utilisation. Hierarchical multiple regressions were conducted to evaluate whether tactile threshold and false alarms were independently associated with symptom reporting, health anxiety and health care utilisation. Total PHQ-15, HAI and HCU score were the target variables; average tactile threshold and false alarm rate in each block and light condition were predictor variables.

Exploratory analysis. In order to investigate the relationship between somatic awareness and attentional disengagement, correlations were conducted between false alarm rates and average tactile threshold on the SSDT and visual and tactile performance on the MBT. Hierarchical regressions controlling for covariates were conducted to follow-up significant relationships.

Overall. Two-tailed tests of significance are reported throughout, an alpha level of .05 was used, and measures of effect size are all Pearson's *r*, or for non-parametric correlations Spearman's *r; r*≥.10 was considered a small, *r*≥.30 a medium, and *r*≥.50 a large effect. All statistical analyses were conducted using SPSS version 20.0 (IBM SPSS Inc., Chicago, IL).

5.5. Results

5.5.1. *Preliminary analysis of SSDT – Time 1(T1)*

Reliability and validity of the tactile threshold

The tactile threshold test-retest correlation was r_{tt} = .74 (p <.001), and there was no significant difference between mean pre and post tactile threshold (z = -.89, p>*.05*). This

indicated that tactile thresholds were reliably determined by the computerised forced choice procedure. Table 5.1 presents descriptive statistics for the T1 SSDT data. The median block 1 light-absent hit rate was within the 40-60% range which is considered to represent tactile threshold (see Table 5.1 below). However, six participants had hit rates < 10% and 18 participants had hit rates > 90% in block 1 light-absent trials[5]. Therefore 76.1% of participant thresholds were within the expected range.

Table 5.1 *Mean (SD): hit rate, false-alarms, d' (tactile sensitivity) and c (tendency to say yes) in light-absent and light-present conditions of the SSDT. Test of difference (effect size) for effect of block and light on: hits, false alarms, d', and c (n=109).*

	% hits	**% false alarms**	***d'***	***c***
Block 1				
Light-absent	54.94 (27.45)	13.74 (11.79)	1.43 (.82)	.55 (.59)
Light-present	64.11 (25.14)	15.92 (12.98)	1.60 (.96)	.34 (.54)
Block 2				
Light-absent	55.62 (27.89)	12.21 (11.00)	1.50 (.95)	.58 (.61)
Light-present	66.51 (26.99)	12.91 (10.33)	1.86 (1.03)	.35 (.58)
Effect of block				
Light-absent	-1.21	-1.55	-0.92[a]	-0.69[a]
Light-present	-1.21	-2.51** (-.17)	-3.16** (-.22)[a]	-0.36[a]
Effect of light				
Block 1	-5.29*** (-.36)	-1.81	-2.27** (-.21)[a]	5.60*** (.46)[a]
Block 2	-6.18*** (-.47)	-0.98	-5.66*** (-.38)[a]	6.11*** (.50)*a*

*$p < .05$. ** $p < .01$. *** $p < .001$. *Significant differences are Wilcoxon matched pairs because of non-normal distributions of the data and* [a] *indicates t-test because data was normally distributed.*

The effect of block

For light-absent trials there were no significant differences between block 1 and 2 for any of the SSDT variables (see Table 5.1 above for all differences and effect sizes). For light-present trials, there were significant differences for false alarm rate, which decreased,

[5] Analyses were conducted with and without participants who had hit rates < 10% and > 90% and no significant differences were found, therefore these participants were not excluded from the analysis.

and tactile sensitivity, which increased, in block 2. Light-present hit rate and the tendency to say yes were not significantly different between block 1 and 2. Therefore, the increase in tactile sensitivity in block 2 appears to be due to the reduction in false alarms. Because there were significant differences in false alarm rates and tactile sensitivity between blocks 1 and 2 subsequent analyses were conducted for each block separately.

The effect of the visual stimulus

In block 1 and 2 participants' hit rate tactile sensitivity (*d'*) and tendency to say yes (*c*) were all significantly increased by the presence of the light. False alarm rate was not significantly increased by the presence of the light. These findings are consistent with previous SSDT studies providing further evidence of the validity of the threshold procedure and the reliability of the paradigm.

5.5.2. *Preliminary analysis of SSDT – Time 2*

Reliability and validity of the tactile threshold

The tactile threshold test-retest correlation was highly significant (r_{tt} = .71, p <.001) and there was no significant difference between mean pre and post tactile threshold (z = -.92, p>.05). This indicated that tactile thresholds were reliably determined by the computerised forced choice adaptive procedure. Table 5.2 below presents descriptive statistics for the T2 data. The median block 1 light-absent hit rate was within the 40-60% range which is considered to represent tactile threshold (see Table 5.2 below). However, five participants had hit rates < 10% and five participants had hit rates > 90% [6]. Therefore 86.1% of participant thresholds were within the expected range.

The effect of block

For light-absent and light-present trials there were no significant differences between block 1 and 2 for any of the SSDT variables (see Table 5.2 below for differences).

[6] Analyses were conducted with and without participants who had hit rates < 10% and > 90% and no significant differences were found, therefore these participants were not excluded from the analysis.

The effect of the visual stimulus

In block one, participants' hit rate and tendency to say yes were significantly increased by the presence of the light. There were non- significant increases in false alarm rate and tactile sensitivity.

In block two, participants' hit rate, false alarm rate and tendency to say were significantly increased by the presence of the light. Tactile sensitivity was not significantly increased by the presence of the light

Table 5.2 Median (IQR): hit rate, false-alarm rate, d*' (tactile sensitivity) and* c *(tendency to say yes) in light-absent and light-present conditions of the SSDT. Test of difference (effect size) for effect of block and light on: hits, false alarms,* d*', and* c *(n =70).*

	% hits	**% false alarms**	***d'***	***c***
Block 1				
Light-absent	54.76 (33.00)	11.90 (19.00)	1.44 (0.96)	.57 (.54)
Light-present	69.05 (37.00)	11.90 (23.00)	1.54 (0.99)	.37 (.57)
Block 2				
Light-absent	57.14 (36.00)	09.52 (14.00)	1.40 (0.88)	.56 (.55)
Light-present	64.29 (46.00)	11.90 (19.00)	1.48 (1.04)	.35 (.57)
Effect of block				
Light-absent	-0.51	-0.32	1.07	.27
Light-present	-0.19	-0.48	0.62	.42
Effect of light				
Block 1	-4.11*** (-.50)	-1.90	-1.16[a]	4.15*** (.47)[a]
Block 2	-4.46*** (-.54)	-2.53** (-.31)	-1.77[a]	5.07*** (.52)[a]

**p < .05. ** p < .01. *** p < .001. Significant differences are Wilcoxon matched pairs because of non-normal distributions of the data and [a] indicates t-test because data was normally distributed.*

The inferential statistics conducted for both T1 and T2 suggest that tactile thresholds were reliably determined. The effect of the light is consistent with previous findings which supports the validity of the paradigm. The significant effect of block at T1 and significant effect of light at T2 suggests that false alarm rate should be analysed separately for each block and light condition in subsequent analyses.

5.5.3. *Main analyses – T1*

Are tactile threshold and false alarm rate associated with symptom reporting, health anxiety and health care utilisation?

The preliminary analyses demonstrated that pre- and post- tactile threshold were highly related; an average of pre and post tactile threshold was therefore taken and used in subsequent analyses. Table 5.3 below, displays correlations between tactile threshold, false alarm variables, symptom reporting, health anxiety and health care utilisation. Correlations between average tactile threshold (*Mdn* = -2900.00), symptom reporting, health anxiety and health care utilisation were all non-significant. There were significant positive correlations between block 2 false alarms, symptom reporting and health anxiety, but not for block 1, where correlations were all non-significant for symptom reporting, health anxiety and health care utilisation. However, the preliminary analyses revealed a significant decrease in light-present false alarms in block 2 and a non-significant decrease in light-absent false alarms. These findings suggest that there was a change in the tendency to make false alarms across blocks. To investigate whether the sustained tendency to make false alarms across the task was associated with symptom reporting, health anxiety and health care utilisation, change in false alarm rate was calculated by subtracting block 1 false alarm rate from block 2 false alarm rate (positive scores indicating that false alarms increased in block 2, negative scores indicating that false alarms decreased, and zero indicating no change). Light-absent and light-present change in false alarms were significantly correlated with symptom reporting and light-present change was significantly correlated with health anxiety.

Table 5.3 Correlations between tactile threshold, false alarm (FAs; block 1 and 2) and false alarm change (FA Change) variables in light-absent (LA) and light-present (LP) conditions, symptom reporting (PHQ-15), health anxiety (HAI) and health care utilisation (HCU) (n =108).

Measure	*PHQ-15*	*HAI*	*HCU*
Threshold	-.12	.03	.07
FAs			
Block 1			
LA	.01	.12	-.15
LP	.02	-.01	.01
Block 2			
LA	.20*	.22*	-.02
LP	.25*	.32**	.02
FA Change			
LA	.22*	.11	.16
LP	.21*	.29**	.03

*p <.05. ** p <.001.

Are tactile threshold and false alarm rate independent predictors of symptom reporting, health anxiety and health care utilisation when controlling covariates?

Hierarchical regressions were carried out separately taking symptom reporting, health anxiety and health care utilisation as the target variables. Tactile threshold, block 2 false alarm rate and change in false alarm rate, in both light conditions, were taken as predictors in step 2, with covariates (age, gender, CCI, STAI-T, BSI-A and BSI-D) in step 1. In addition to these covariates, health anxiety was controlled for in the analyses focusing on symptom reporting, symptom reporting was controlled for when focusing on health anxiety, and both symptom reporting and health anxiety were controlled for when focussing on health care utilisation. The same analyses were repeated at T2 and longitudinally. In each of the analyses, the regression diagnostics indicated that the assumptions of multiple-regression had been met. To aid clarity, summary regression tables have been provided throughout; full details of each of the regressions can be found in Appendix D, Section D.3.

Predicting symptom reporting

FA change in the light-absent condition was a significant unique predictor of symptom reporting and its inclusion led to a significant increase in the predictive power of

the regression equation. Gender (*B range = 0*.40-0.42, *all SEB* range = 0.13*, β range =* 0.23-0.24, all *p's* < .05), medical conditions (*B range = 0*.42-0.43, *all SEB* = 0.13*, β = 0*.25- 0.26, all *p's* < .05), health anxiety (*B range* = 0.16-0.19, *SEB* range = 0.08-0.09*, β =* .17-.20, all *p's* < .05), and anxiety (all *B =0.05*, *all SEB* = .02*, β = 0.30-0.33*, all *p's* < .05), were all unique predictors of symptom reporting in the final regression equations. The direction of the coefficients was positive, which indicates that increased light-absent FA rate across the task, being female, the presence of a medical condition, increased health anxiety and increased anxiety were independently associated with increased symptom reporting.

Predicting health anxiety

Block 2 light-present FAs and light-present FA change were significant unique predictors of health anxiety and their inclusion led to a significant increase in the predictive power of the regression equation (see Table 5.4 below). Symptom reporting (*B range = 0*.22-0.27, *SEB* range = 0.12-0.27*, β range* = 0.21-0.25, all *p's* < .05) and trait anxiety (all *B = 0.02*, *SEB* range = 0.01-0.02*, β = 0.*26- 0.28, all *p's* < .05) were also unique predictors of health anxiety in the final regression equations. The direction of the coefficients was positive, indicating that greater block 2 light-present FAs, change in light-present FA rate across the task, symptom reporting and trait anxiety are associated with increased health anxiety.

Predicting health care utilisation

None of the predictors led to a significant improvement in the regression equation. However, gender (all *B = 0*.01, *SEB* range = 0.00-0.01*, β range* = 0.19-0.22, all *p's* < .05) and age (*B range = 0.15-0.16*, *all SEB* = 0.08*, β = 0.*19- 0.20, all *p's* < .05) were unique predictors of health care utilisation in the final regression equations. The direction of the coefficients was positive, indicating that being female and older were independently associated with increased health care utilisation.

Table 5.4 Summary of hierarchical regressions predicting T1 symptom reporting (PHQ-15), health anxiety (HAI) and health care utilisation (HCU) from T1 SSDT task performance, controlling for T1 covariates (n=108). Full details of regressions and covariates can be found in Appendix D, Section D.3.

Measure	*PHQ-15*			*HAI*			*HCU*		
	B	SEB	β	B	SEB	β	B	SEB	β
Threshold	-0.01	.00	-.03	0.00	0.00	.10	-0.01	0.00	11
FAs									
B2 LA	0.70	0.53	.10	1.04	0.64	.14	-0.20	0.29	-.06
B2 LP	-0.06	0.56	-.01	1.31	0.65	.16*	-0.38	0.30	-.11
LA change	1.55	0.59	.19*	0.57	0.76	.06	0.38	0.34	.10
LP change	0.32	0.52	.05	1.75	0.58	.25*	-0.18	0.28	-.06

*$p < .05$. ** $p < .001$.

5.5.4. *Main analysis – T2*

Are tactile threshold and false alarm rate associated with symptom reporting, health anxiety and health care utilisation?

Table 5.5 below, displays correlations between tactile threshold, false alarm variables, symptom reporting, health anxiety and health care utilisation. There were significant positive correlations between change in false alarm rate in both light conditions and health anxiety; however, correlations between average tactile threshold, symptom reporting, health anxiety and health care utilisation were all non-significant.

Table 5.5 Correlations between tactile threshold, false alarm variables in light-absent (LA) and light-present (LP) conditions, symptom reporting, health anxiety and health care utilisation (n =70).

	PHQ-15	*HAI*	*HCU*
Threshold	-.01	-.02	.18
FAs			
B1			
LA	.06	-.13	-.14
LP	-.04	-.12	.02
B2			
LA	.14	.10	-.10
LP	.15	.17	.06
FA Change			
LA	.17	.27*	.21
LP	.18	.29*	.06

*$p < .05$. ** $p < .001$.

Are tactile threshold and false alarm rate independent predictors of symptom reporting, health anxiety and health care utilisation when controlling covariates?

Predicting symptom reporting

None of the predictors led to a significant improvement in the regression equation. Age (all *B* = -*0*.02, *all SEB* = 0.01, *β range* = -0.18, all *p's* ≤ .05), health anxiety (*B range = 0*.24-0.26, *SEB range* = 0.11-0.12, *β = 0*.27- 0.30, all *p's* < .05) and trait anxiety (all *B range* = 0.02, *all SEB* = 0.01, *β range* = .24-.26, all *p's* < .05) were unique predictors of symptom reporting in the final regression equations. For age the direction of the co-efficient was negative indicating that younger participants reported increased levels of symptoms. For both health anxiety and trait anxiety the direction of the co-efficient was positive, indicating that increased health anxiety and increased trait anxiety were associated with increased symptom reporting.

Predicting health anxiety

Light-present FA change was a significant unique predictor of health anxiety and its inclusion led to a significant increase in the predictive power of the regression equation (see Table 5.6 below). Symptom reporting (*B range = 0*.28-0.31, *SEB* range = 0.13-0.14, *β range* = 0.25-0.27, all *p's* < .05) was also a unique predictor of health anxiety in the final

regression equations. The direction of the coefficients was positive; this indicates that the increased tendency to make light-present false alarms across the task, and increased symptom reporting, were associated with increased health anxiety.

Predicting health care utilisation

None of the predictors led to a significant improvement in the regression equation. Gender (all *B = 0*.01, *all SEB* = 0.01*, β range* = 0.25-0.26, all *p's* < .05) and health anxiety (*B range = 0.15-0.17, all SEB* = 0.07*, β = 0.*34- 0.39, all *p's* < .05) were unique predictors of health care utilisation in the final regression equations. The direction of the coefficients was positive, indicating that being female and increased health anxiety were independently associated with increased health care utilisation.

Table 5.6 Summary of hierarchical regressions predicting T2: symptom reporting (PHQ-15), health anxiety (HAI) and health are utilisation (HCU) from T2: SSDT task performance and controlling for T2 covariates (n = 70). Full details of regressions and covariates can be found in Appendix D Section D.3.

Measure	*PHQ-15*			*HAI*			*HCU*		
	B	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Threshold	-0.01	0.00	-.04	0.00	0.00	-.16	0.00	0.00	.18
FAs									
B2 LA	0.15	0.61	.02	-0.06	0.68	-.01	-0.28	0.39	-.09
B2 LP	-0.09	0.44	-.02	0.43	0.49	.08	0.08	0.28	.03
LA change	0.03	0.71	.00	1.26	0.75	.14	0.36	0.45	.09
LP change	-0.14	0.51	-.03	1.32	0.51	.22*	0.15	0.32	.06

*p < .05. ** p < .001.

5.5.5. *Main analysis - Longitudinal*

Are tactile threshold and false alarm rate at T1 associated with symptom reporting, health anxiety and health care utilisation at T2?

Table 5.7 below, displays correlations between T1 tactile threshold, false alarm variables, T2 symptom reporting, health anxiety and health care utilisation. There were significant positive correlations between block 2 light-present false alarms and health anxiety, as well as change in false alarm rate in the light-absent condition and health care utilisation.

Table 5.7 Correlations between T1: tactile threshold, false alarm variables in light-absent (LA) and light-present (LP) conditions and T2: symptom reporting, health anxiety and health care utilisation (n=70).

	Time 2: *PHQ-15*	*HAI*	*HCU*
Time 1:			
Threshold	-.10	.16	-.02
FAs			
B1			
LA	-.03	.05	-.10
LP	.01	.10	.05
B2			
LA	.13	.20	.12
LP	.16	.31**	.16
Change			
LA	.18	.13	.24*
LP	.13	.13	.13

*$p < .05$. ** $p < .001$.

Are tactile threshold and false alarm rate independent predictors of symptom reporting, health anxiety and health care utilisation when controlling for T1 covariates?

The analyses conducted at both T1 and T2 were repeated. In order to investigate clues to causality, T1 SSDT performance variables were taken as predictors, T2 symptom reporting, health anxiety and health care utilisation were taken as the target variables, and T1 symptom reporting, health anxiety and health care utilisation as well as the covariates in the cross-sectional analyses were controlled for (e.g., when predicting T2 symptom reporting, we controlled for T1 symptom reporting, age, gender, medical conditions, health anxiety, trait and state anxiety and depression).

Predicting symptom reporting

None of the predictors led to a significant improvement in the regression equations. T1 physical symptom reporting was a positive unique predictor of T2 physical symptom reporting (*B = 0.69/0.67, all SEB* = 0.14*, β = .61/.63*, all *p's* ≤ .001) the direction of the co-efficient was positive, indicating that increased T1 symptom reporting predicted increased T2 symptom reporting.

Predicting health anxiety

None of the predictors led to a significant improvement in the regression equations. T1 health anxiety was a positive unique predictor of T2 health anxiety (*B range = 0.84-0.86, all SEB* = 0.10*, β range = .77-82,* all *p's* ≤ .001) the direction of the coefficients was positive, indicating that increased T1 health anxiety predicted increased T2 health anxiety.

Predicting health care utilisation

None of the predictors led to a significant improvement in the regression equations. T1 health care utilisation (all *B = 0.91/0.92, all SEB* = 0.11*, all β = .80/.81*, all *p's* ≤ .001), T1 trait anxiety (all *B = -0.01, all SEB* = -0.20*, all β = -.76*, all *p's* ≤ .05) and T1 depression (all *B = 0.03, all SEB* = 0.01*, β range = .44-.46*, all *p's* ≤ .05) were unique predictors of T2 health care utilisation. The direction of the health care utilisation and depression coefficients was positive, indicating that increased T1 health care utilisation and depression predicted increased T2 health care utilisation. The direction of the trait anxiety coefficient was negative indicating that decreased T1 trait anxiety was associated with increased T2 health care utilisation.

Table 5.8 Summary of hierarchical regressions predicting T2: symptom reporting (PHQ-15), health anxiety (HAI) and health are utilisation (HCU) from T1: SSDT task performance and controlling for T1 covariates (n=71). Full details of regressions and covariates can be found in Appendix D, Section D.5.

	PHQ-15			***HAI***			***HCU***		
	B	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Threshold	0.00	0.00	.02	0.00	0.00	.09	0.00	0.00	-.05
FAs									
B2 LA	0.41	0.80	.05	1.06	0.69	.11	0.19	0.36	.05
B2 LP	-0.30	0.82	-.03	0.85	0.72	.08	0.25	0.37	.06
LA change	1.18	0.82	.13	0.27	0.73	.03	0.12	0.38	.03
LP change	-0.86	0.82	.11	-0.80	0.73	-.09	-0.03	0.38	-.01

*p < .05. ** p < .001.

The significant cross-sectional relationships between FAs, symptom reporting and health anxiety found at both T1 and T2 were not found longitudinally when controlling for T1 covariates. This suggests that the tendency to experience FAs may be a consequence of symptom reporting and health anxiety rather than a cause, or that there may be a third variable that is responsible for both false alarms, symptom reporting and health anxiety. In

order to investigate the former hypothesis we investigated whether T1 symptom reporting, health anxiety and health care utilisation predict T2 FAs when controlling for T1 FAs.

Predicting False Alarms

The inclusion of T1 symptom reporting led to a significant improvement in the regression equation when predicting T2 block two light-absent false alarms and a near significant improvement in the regression equation when predicting T2 light-absent false alarm change (see summary Table 5.9 below). This suggests that light-absent false alarms may be a consequence of physical symptom reporting rather than a cause.

The inclusion of health anxiety also led to a significant improvement in the regression equations when predicting T2 light-absent and light-present FA change. It is interesting to note that T1 light-absent and light-present FA change were not unique predictors of T2 FA change (see appendix D, Section D.5 for full details), unlike T1 B2 FAs which were significant predictors of T2 B2 FAs throughout. T1 and T2 false alarm change across blocks were not associated with one another (See Appendix D, Section D.4). These results suggest that false alarm change across blocks may also be a consequence of health anxiety. Health anxiety was not a significant predictor of T2 B2 FAs. This suggests that block 2 false alarms are not a consequence of health anxiety.

The inclusion of health care utilisation did not lead to a significant improvement in any of the regression equations this suggests that false alarms are not a consequence of health care utilisation.These results suggest that FAs may be a consequence, rather than a cause, of physical symptom reporting and health anxiety.

Table 5.9 *Summary of hierarchical regressions predicting T2: FA variables from T1: symptom reporting, health anxiety and health care utilisation controlling for covariates (n = 70). Full details of regressions and covariates can be found in Appendix D, Section D.5.*

	T2 FAs:											
	B2 LA			B2 LP			LA change			LP change		
	B	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
T1:												
PHQ-15	-0.01	0.03	-.06	0.07	0.03	.30*	-0.05	0.03	-.32	0.00	0.04	.01
HAI	-0.00	0.02	-.01	0.01	0.03	.06	0.04	0.02	.33*	0.07	0.03	.41*
HCU	-0.07	0.05	-.21	-0.00	0.06	-.01	0.01	0.04	.04	0.03	0.06	.07

*p<.05. ** p <.001.

5.5.6. *Exploratory analysis*

Table 5.10 and 5.11 below, display zero-order correlations between MBT performance variables and SSDT performance variables at both time points. At T1 there were no significant relationships between disengagement and either somatic distortion or tactile threshold. At T2, there were also no significant relationships between disengagement and somatic distortion, however, tactile threshold was significantly positively correlated with attentional disengagement in all of the picture conditions. This suggests that difficulties disengaging from material irrespective of its content were associated with increased tactile thresholds. However, the results of Chapter 4 suggest that age is a significant moderator of performance on the MBT (e.g. age is associated with slower performance in general). Post hoc analysis revealed that age was significantly positively correlated with average tactile threshold at T2 (r_s = .39, p = .001), but not at T1 (r_s = .14, p = .16). This suggests that as age increased, tactile thresholds also increased (i.e. became less sensitive). Thus age also appears to be a moderator of tactile threshold. In line with the analysis conducted in Chapter 4, post hoc hierarchical multiple regressions were conducted controlling for relevant covariates and performance in the neutral-scene condition as a control for general performance. Six separate hierarchical regressions were carried out, each taking tactile threshold as the target variable and disengagement variables as predictors in step 2; with covariates (age, gender, CCI, PHQ-15, HAI, STAI-T, BSI-A, BSI-D and neutral-scene performance) in step 1.

Table 5.10 Zero-order correlations between T1 MBT variables and SSDT variables (n =104).

	Block 1		Block 2				Ave.
	Light-absent FA	Light-present FA	Light-absent FA	Light-present FA	Light-absent change	Light-present change	Tactile threshold
Tactile targets							
- Neutral-body	-.00	.02	-.00	.04	-.06	.08	.03
- Neutral-scene	.02	.05	.06	.05	-.01	.05	.02
- Threat-body	.03	.07	.00	.05	-.08	.03	.11
- Threat-scene	-.06	.07	.00	.04	-.02	.03	.08
Visual targets							
- Neutral-body	-.05	-.01	-.06	-.01	-.09	.05	-.01
- Neutral-scene	.01	.05	-.00	.09	-.10	.08	-.05
- Threat-body	-.14	-.06	-.04	.01	.03	.11	.02
- Threat-scene	-.09	-.01	-.02	.05	.01	.14	.02

*$p < .05$. ** $p < .001$

Table 5.11 Zero-order correlations between T2 MBT variables and SSDT variables (n = 70).

	Block 1		Block 2				Ave.
	Light-absent FA	Light-present FA	Light-absent FA	Light-present FA	Light-absent change	Light-present change	Tactile threshold
Tactile targets							
- Neutral-body	-.04	-.02	.02	.06	.03	.05	.37*
- Neutral-scene	-.06	-.04	-.09	-.01	-.03	.01	.44**
- Threat-body	-.05	.01	-.05	.02	-.02	-.01	.36**
- Threat-scene	-.03	-.01	-.04	.01	-.03	-.00	.43**
Visual targets							
- Neutral-body	-.12	-.09	-.06	-.09	.03	-.00	.39**
- Neutral-scene	.02	-.00	.03	.01	.01	.01	.35**
- Threat-body	-.04	-.05	.02	-.04	.03	-.01	.36**
- Threat-scene	-.06	-.10	.02	-.07	.06	.01	.48**

*$p < .05$. ** $p < .001$

Predicting T2 tactile threshold

The inclusion of the tactile performance variables did not lead to a significant increase in the predictive power of the regression equation (see Table 5.11 below). However, when tactile performance in threatening and neutral body-relevant conditions was included in the regression equations, the predictive power of neutral body-irrelevant performance increased such that it became a positive unique predictor in both models (both *Bs' = 7215.71/5364.82*, *both SEBs* = 2851.48/2177.60*, both βs'* = .89/.67, both *p's* < .05). Age (*B range = 55.36-59.78*, *SEB* range = 24.68-25.27*, β range* = .41-.45, all *p's* < .05) and state anxiety (*B range = 54.90-56.85*, *SEB* range = 24.96-25.89*, β range* = .41-.42, all *p's* < .05) were also positive unique predictors of tactile threshold in the final regression equations. This suggests that poorer disengagement in the neutral body-irrelevant condition and increased age and anxiety are associated with less sensitive tactile thresholds.

The inclusion of visual performance in the threatening body-irrelevant condition led to a significant improvement in the predictive power of the regression equation (see Table 5.12 below). The direction of the coefficient was positive which suggests that poorer visual disengagement in this condition was associated with less sensitive tactile thresholds. The inclusion of threatening body-irrelevant performance also led to a simultaneous improvement in the predictive power of neutral body-irrelevant performance and trait anxiety, such that trait anxiety became a significant positive predictor (*B = 57.69*, *SEB* = 25.96*,* β = .43, $p < .05$). When visual performance in neutral and threatening body-relevant conditions were included there was not a significant improvement in the regression equations; however, in line with analysis of tactile performance, age (both *Bs' = 18.39/19.94, both SEBs* = 8.34/8.67*, both* β = .26/.29, both *p's* < .05) and anxiety (*B = 57.71/57.69, both SEBs* = 25.62/25.96*,* β = .43, both *p's* < .05) were positive unique predictors in both models.

Table 5.12 Summary of hierarchical regressions predicting T2: average tactile threshold from T2: MBT performance and controlling for T2 covariates (n=70). Full details of regressions and covariates can be found in Appendix D, Section D.5.

	Tactile threshold		
	B	*SEB*	*β*
Tactile targets			
Neutral-body	-5269.19	2878.36	-.65
Threat-body	551.50	2433.88	.07
Threat-scene	786.29	2742.26	.10
Visual targets			
Neutral-body	2865.36	2236.98	.36
Threat-body	551.50	2433.88	.07
Threat-scene	6875.46	2550.58	.77*

*$p < .05$. ** $p < .001$.

5.6. Discussion

5.6.1. *Reliability and validity of the tactile thresholding procedure*

The tactile threshold was reliably determined at both T1 and T2, as indicated by the high test-retest correlations and non-significant tests of difference. The mean light-absent

hit rate of the first test-half at both T1 and T2 was within the 40-60% range for single interval trials. Thus the probability of detecting the tactile stimulus was above chance, but remained difficult enough to induce uncertainty. This suggests tactile threshold was adequately determined. At T1 22% and at T2 14.5% of the participants had hit rates greater than 90% or lower than 10%. Therefore, at T1 the threshold procedure was not as effective as anticipated, since 78% of the participants had thresholds within the expected range (expected > 80%).

The use of a two-alternative forced choice task is an improvement on the original procedure, which used a single interval yes/no task. The two-alternative forced choice task circumvents the possibility of response bias affecting the tactile threshold (Katzer et al., 2011). In the experimental phase of the SSDT, single interval yes/no trials are presented, which introduces the effects of response bias. Therefore some deviation in hit rate on experimental trials compared to the hit rate determined in the threshold is expected. However, the procedure may benefit from participants completing a small number of dummy single interval yes/no light-absent trials prior to starting the experimental phase of the SSDT. The experimenter could check the hit rate of the dummy trials and if participants' hit rates were found to be outside the upper or lower limits (90/10) appropriate adjustments could be made to the tactile stimulation level. Such an adaptation may reduce the number of participants with hit rates outside the upper and lower limits, to a more acceptable level (e.g. less than 20%). The inclusion of dummy trials would, however, increase the length of the task, which may affect gradual changes in performance over time, such as the change in false alarm rates observed at T1.

Although some improvements to the procedure could be implemented, the introduction of a fully computerised procedure has minimised potential experimenter effects and has also allowed an empirical measurement of individual tactile threshold to be derived. Overall, a more objective and reliable procedure for determining tactile threshold has been introduced.

5.6.2. *Reliability and validity of the SSDT*

Consistent with previous SSDT studies the presentation of the light increased hit rates (at both T1 and T2), tactile sensitivity (T1), and the tendency to say yes (T1 and T2; e.g. Brown et al., 2010; Brown et al., 2012). These results provide further evidence of both the validity of the threshold procedure and the reliability of the paradigm.

False alarm rate was not significantly increased by the presence of the light at T1; this is consistent with previous SSDT research with clinical symptom reporters (Katzer et al., 2012; Brown et al., 2012). At T2, the presence of the light did lead to a significant increase in false alarm rate. SSDT research with non-clinical symptom reporters and healthy participants has found the effect of the light on false alarm rates to be inconsistent. Some studies have found that the presentation of the light significantly increased false alarm rates (Lloyd et al., 2008; Mckenzie et al., 2011; Brown et al., 2012); others have not (Brown et al., 2010; Katzer et al., 2011). Katzer et al. (2012) found that SFD patients' false alarm rates were less affected than controls by the presentation of the light. This suggests that clinical high symptom reporters may be less affected by the presence of the light when making decisions about the presence or absence of an ambiguous tactile sensation.

Hit rate was not consistently associated with false alarm rates (see Appendix D, Section D.2), indicating that the strength of the tactile stimulus was not directly related to false alarm rate in this sample. False alarm rates in the light-absent and light-present trials were highly correlated (see Appendix D, Section D.2). This is consistent with previous SSDT research and indicates that similar processes underlie false alarms in both trial types (McKenzie et al., 2010). False alarms were also highly correlated between T1 and T2 (see Appendix D, Section D.2). False alarms have previously been found to be correlated between testing sessions spaced over a month apart (McKenzie et al., 2010). This study is the first to demonstrate that false alarm rates are correlated over a more substantial time period. This finding further supports the notion that the tendency to experience distortions in somatic awareness is a trait-like characteristic (Brown, 2004).

At T1 there was a significant effect of test half on both false alarms and tactile sensitivity in the light-present condition, such that false alarm rates decreased and tactile sensitivity increased in block 2. Hit rates and response bias remained stable across test-halves, however. This indicates that the decrease in false alarm rates led to the increase in tactile sensitivity. This pattern of results is similar to that observed in Chapter 3 where false alarms decreased and tactile sensitivity increased in the light-absent condition on block 2 of the task. At T2 there was not a significant effect of test-half on performance.

Differences between test-halves have not been reported (or obviously evaluated) in the majority of SSDT studies (Brown et al., 2010; Brown et al., 2013; Katzer et al., 2011). However, a study by Katzer et al., (2012) similarly found a reduction in false alarms on block 2 of the task. Although the tendency to experience false alarms has been found to be a relatively stable trait like characteristic, it may be that this characteristic is only measured

reliably after initial practice on the task. One possibility is that participants became more stringent on the second half of the task; however, response bias (tendency to say yes) remained relatively stable, suggesting that the reduction in false alarms observed here was specifically related to better judgment of when the stimulus was absent (but only when the light was present). The fact that there was an overall reduction in false alarms on block 2 at T1 and no significant differences between blocks at T2 suggests that false alarms are not the result of learnt associations between the light and the tactile stimulus, that is, they do not appear to be an artefact of the task. This would suggest that false alarms are a result of everyday associations between multi-sensory experiences (McKenzie et al., 2012). This finding further supports the idea that the tendency to experience false alarms may be a trait like characteristic. The finding that some participants' false alarm rates improved across the task suggests that some participants were able to modify top-down expectancies based on prior multi-sensory experiences, whilst others were not. In order to investigate whether the sustained tendency to make false alarms across the task was associated with symptom reporting, health anxiety and health care utilisation, change in false alarm rate was included as an independent variable in subsequent analyses.

In sum, the findings of the preliminary analysis indicate that the thresholding procedure and the SSDT are both reliable and valid. However, some improvements could be made to the thresholding procedure to reduce the number of participants with thresholds outside the upper and lower limits. Furthermore the findings suggest that future SSDT studies should check whether performance between test-halves differs.

5.6.3. *Evaluation of research hypotheses*

Tactile threshold was not associated with symptom reporting, health anxiety or health care utilisation either cross-sectionally or longitudinally. This suggests that symptom reporting, health anxiety and health care utilisation are not associated with an enhanced ability to detect subtle somatosensory signals. The present finding is in contrast to a recent SSDT study by Katzer et al., (2012) that found SFD patients had lower tactile thresholds than healthy controls. However, it is consistent with their earlier finding that non-clinical symptom reporting was not associated with tactile threshold (Katzer et al., 2011).

At T1, both light-absent and light-present false alarms were significantly correlated with both symptom reporting and health anxiety. However, these correlations only

emerged in the second test-half. Furthermore, change in false alarm rate between test-halves in both light conditions was associated with symptom reporting. Change in false alarm rate in the light-present condition was also associated with health anxiety. The association between light-absent change in false alarm rate and symptom reporting remained significant when controlling for relevant covariates (age, gender, medical conditions, health anxiety, trait anxiety, state anxiety and depression), as did the association between light-present false alarms, light-present false alarm change and health anxiety.

At T2 no significant relationships were found between false alarms in either test half or light condition and symptom reporting, health anxiety or health care utilisation. However, false alarm change in both light conditions was significantly positively associated with health anxiety. Furthermore, when relevant covariates were controlled for the association between false alarm change in the light-present condition and health anxiety remained.

The longitudinal analyses revealed significant correlations between false alarms in the light-present condition of block 2 at T1 and health anxiety at T2. In addition, change in false alarm rate in the light-absent condition at T1 was significantly associated with health care utilisation at T2.

The consistent finding that significant correlations between false alarms, symptom reporting and health anxiety only emerged in the second test-half is interesting particularly since an overall reduction in false alarms was found in block 2 at T1. This suggests that those whose judgement of stimulus absent periods improved reported fewer symptoms and were less health anxious, while those whose judgement remained the same or became poorer reported more symptoms and were more health anxious. It is possible that those who improved may have employed a more bottom-up strategy (i.e. greater attention to bottom-up sensory information) in order to make more accurate judgements regarding stimulus absent trials (McKenzie et al., 2012). Those whose false alarm rates remained the same or increased across test-halves may have employed a more top-down strategy that involved attending to cognitive representations of the touch or other factors such as expectations to guide their judgements. This top-down strategy may have led to more erroneous stimulus present judgements to be made. Irrespective of the test half in which the relationship between false alarms, symptom reporting and health anxiety has emerged, it is clear that high symptom reporters have a general tendency to make more false alarms than low symptom reporters on the SSDT.

There appears to be a robust cross-sectional relationship between the tendency to experience distortions in awareness (false alarms), physical symptom reporting and health anxiety. These relationships were independent of covariates and one another. Therefore with regards to symptom reporting the effects seem to pertain specifically to 'functional somatisation' rather than to 'hypochondriachal somatisation' or 'presenting somatisation' (Kirmayer & Robbins, 1991). That is, the effect is not explained by concurrent health anxiety, trait anxiety, state anxiety or depression. With regards to health anxiety the observed effects pertain specifically to health anxiety and not to 'functional somatisation' or 'presenting somatisation'. This study adds to a growing evidence base which supports these relationships (Brown, et al., 2010; Katzer et al., 2011; Brown et al., 2012; Katzer et al., 2013).

The tendency to experience somatic distortions at T1 was significantly correlated with both health anxiety and health care utilisation at T2. When T1 covariates were controlled for T1 somatic distortions did not predict T2 symptom reporting, health anxiety or healthcare utilisation. These results suggest that somatic distortion may be a consequence rather than a cause of symptom reporting, health anxiety and health care utilisation, or that there is a third unaccounted for variable that is responsible for both. In order to investigate the former hypothesis we investigated whether T1 symptom reporting, health anxiety and health care utilisation predicted T2 somatic distortion when controlling for T1 somatic distortion and relevant covariates. Both symptom reporting and health anxiety were unique predictors of T2 somatic distortion, however, health care utilisation was not.

The results of this study suggest that increased physical symptom reporting and health anxiety may be a cause of somatic distortion, rather than a consequence. Interestingly the longitudinal relationships between health anxiety, symptom reporting and somatic distortion were independent of one another (as well as other covariates). This suggests that although highly related constructs, symptom reporting and health anxiety predict unique portions of the variance in somatic distortion. Thus it appears that increased physical symptom reporting and health anxiety may have consequences for the perceptual system, such that the experience of physical symptoms and health anxiety increases the tendency to erroneously identify the presence of a somatosensory stimulus when none has been given (i.e., false alarm). The results of this study suggest that, physical symptom reporting and health anxiety are stronger predictors of future symptom reporting, health anxiety and somatic distortion than current somatic distortion itself.

The Brown model suggests that many MUS are, in fact, distortions in somatic awareness brought about by the activation of symptom representations in memory. According to this model, false alarms on the SSDT are caused by the activation of somatosensory representations in memory. Those with lowered activation thresholds may make more false alarms because representations of the tactile stimulus are more easily triggered by cognitive activity such as expectation of a tactile experience or attending to representations of the touch experience in memory. Thus experiencing physical symptoms and health anxiety may lower the activation threshold of somatosensory information stored in the cognitive system, such as, the touch experience. This suggests that those who experience more false alarms may rely more on top-down information when generating somatic awareness. Thus they may have a trait like tendency to experience more somatic distortions (i.e., false alarms). This is further supported by the finding that T1 and T2 false alarms (only on block two of the SSDT) were correlated with one another.

An alternative explanation of the relationship is that the tendency to experience somatic distortions represents an inability to filter out somatosensory noise, which is also responsible for increased symptom reporting (Rief & Barsky, 2005). The two interpretations are not considered to be mutually exclusive (Brown et al., 2012). A filtering deficit may lead to bottom-up information becoming an unhelpful source of evidence when deciding about the presence or absence of ambiguous sensations; as a result, a greater reliance on top-down information when generating somatic awareness may be preferred. However, it does not seem that those who experience greater numbers of symptoms and increased health anxiety have lower (more sensitive) tactile thresholds. That is, they are not able to detect somatosensory signals at weaker levels. Therefore the idea that symptom reporting or health anxiety is due to a deficit in the preconscious selection of somatosensory information (Rief & Barsky, 2005) is not supported by the present findings.

Indeed, it is possible that false alarms represent a combination of both the misattribution of interoceptive somatosensory noise as the exteroceptive tactile stimulus, as well as, the top-down activation of touch representations in memory. This could explain why health anxiety and symptom reporting account for unique portions of the variance in somatic distortion. Health anxiety may be more strongly associated with the misattribution of somatosensory noise as hypothesised by the models of Warwick and Salkovkis (1990) and Barsky and Wyshak (1990). Whereas, symptom reporting may be more strongly associated with the top-down activation of touch representations in memory as hypothesised by the model of Brown (2004).

Importantly, however, biopsychosocial, cognitive attentional and neurobiological models would all predict that the tendency to experience distortions in somatic awareness is a risk factor for the development of physical symptoms and health anxiety, however, this has not been supported by the longitudinal results of the primary care study. Indeed, somatic distortion may be a consequence of physical symptom reporting and health anxiety.

The precise process or processes underlying somatic distortion (i.e., false alarms on the SSDT) remain at present unknown. It seems that those reporting increased symptoms and health anxiety do not have deficits in selection (i.e., they do not demonstrate differences in perceptual threshold on the SSDT). The increased tendency to experience somatic distortion therefore seems to reflects a perceptual bias in selective attention. Somatic distortions, could represent a perceptual decision making bias, perhaps akin to the jumping to conclusions (JTC) biases found in those with a diagnosis of psychosis (e.g., Garety et al., 2007). JTC biases have been measured using probability tasks, and have found that those with a diagnosis of psychosis request less information before forming a decision and are more likely to change their probability estimates in the direction suggested by new evidence. It is possible that a similar perceptual decision making bias underlies increased symptom reporting, health anxiety and somatic distortion. In support of this hypothesis, recent research suggests that those with functional neurological disorders may also display a JTC bias (Parees et al., 2012).

The results of this study indicate that questionnaire measures of both physical symptom reporting and health anxiety predict future symptom reporting and health anxiety more accurately than the experience of false alarms on the SSDT. This suggests that measures of symptom reporting and health anxiety may more accurately capture perceptual decision making biases than false alarms on the SSDT. Future research, could investigate whether a JTC bias exists in high symptom reporters and whether JTC type biases are also found when making decisions involving somatosensory information.

5.6.4. *Evaluation of the exploratory analysis*

No relationship was found between the tendency to experience somatic distortions and attentional disengagement. The results of the present study do not support the results of the pilot study, which found near significant negative relationships between disengagement and somatic distortions.

Interestingly, it was found that less sensitive tactile thresholds on the SSDT were associated with poorer attentional disengagement in all conditions of the MBT. This association between delayed disengagement in the neutral and threatening body-irrelevant conditions and tactile threshold remained when controlling for covariates. This suggests that poorer disengagement from both neutral and threatening body-irrelevant pictures is associated with less sensitive tactile thresholds. This may indicate that poorer disengagement leads to a greater reliance on top-down information when making decisions about sensory experience. That is, those with poorer disengagement may attend away from the body or bottom-up information and this may lead to less sensitive tactile thresholds.

It is also possible that those with poorer disengagement in general may also have had poorer visual disengagement from the visual trial cues on the SSDT. This may reduce attention to the body, thus decreasing bottom-up information and increasing reliance on top-down information. A previous SSDT study did not find that the modality of the trial start cue effected subsequent performance on the experimental phase of the SSDT (McKenzie et al., 2010). However, the McKenzie et al., study was conducted with healthy participants and it is possible that high health care utilisers have poorer disengagement from the visual trial start cues. Further SSDT studies with high health care utilisers should investigate whether the modality of the trial start cue affects subsequent performance, although poorer disengagement may be supramodal.

5.6.5. *Strengths, limitations and future directions*

The main strengths of this study are its prospective design, its use of an objective measure of somatic awareness and its application to a large sample of patients recruited from primary care. In summary, this study sheds new light on the relationship between somatic awareness, symptom reporting, health anxiety and health care utilisation. Using the SSDT, it was found that the increased tendency to experience distortions in somatic awareness was independently cross-sectionally associated with both symptom reporting and health anxiety. These relationships were independent of age, gender, medical conditions, symptom reporting, health anxiety, trait anxiety, state anxiety and depression. Thus the relationship between somatic distortions, symptom reporting and health anxiety appears to be independent of organic factors and psychopathology.

The longitudinal analysis revealed that somatic distortion was not an independent predictor of symptom reporting, health anxiety or health care utilisation. Interestingly,

physical symptom reporting and health anxiety, but not health care utilisation, were independent predictors of somatic distortion. These findings suggest that the cross-sectional relationship between symptom reporting, health anxiety and somatic distortion maybe a consequence of physical symptom reporting and health anxiety, rather than a cause.

Although this was a longitudinal study, it is not possible to definitively establish temporal precedence without employing an experimental design (Kline, 2000). It is possible that the tendency to experience somatic distortions increased physical symptom reporting prior to its measurement; or that the long follow-up period may have obscured a potentially reciprocal relationship between somatic distortion and symptom reporting. Further research employing either a longitudinal design with a shorter follow-up period or an experimental design could be employed to investigate the hypothesised causal relationships between symptom reporting, health anxiety and somatic distortion.

Chapter 6. Investigating the relationship between attentional disengagement, somatic distortion, symptom reporting, health anxiety and health care utilisation: A SEM analysis

6.1. Introduction

The aims of the present chapter were to further support and extend the multiple regression analysis of the data collected in the primary care study, using a structural equation modeling (SEM) analysis. In general, this chapter aimed to shed further light on the complex inter-relationships established in Chapters 4 and 5. More specifically, the aim was to investigate whether the addition of variables measuring both attentional disengagement and the sustained tendency to experience distortions in somatic awareness improve our understanding of factors relevant to symptom reporting, health anxiety and health care utilisation.

The results of the primary care study provide evidence that individual differences in attentional disengagement are associated with health care utilisation and that the sustained tendency to experience somatic distortions is associated with symptom reporting and health anxiety. In Chapter 4, delayed visual disengagement from threatening body-relevant material, and enhanced visual disengagement from neutral body-irrelevant material, were found to be independently associated with health care utilisation. In Chapter 5, the cross-sectional analysis demonstrated that the sustained tendency to experience distortions in light-absent trials (i.e. change in false alarm rate across block 1 and 2) was independently associated with symptom reporting and in light-present trials was independently associated with health anxiety.

Identifying cognitive processes related to symptom reporting, health anxiety and health care utilisation and investigating inter-relationships with other factors may also provide a clearer understanding of the maintenance of MUS. However, using multiple-regression analysis, as was the case in Chapter 4 and 5, only allows the assessment of individual coefficients and does not allow a simultaneous assessment of the relationships between coefficients. In order to address this, SEM was employed here to evaluate a series of hypothesised models specified on the basis of theory, empirical evidence and the findings of Chapters 4 and 5.

SEM allows the overall fit of models to the data to be evaluated, as well as the ability to model mediating variables, and this provides a more robust analysis. The models

assessed the relationships between biological (age, gender & medical conditions), psychopathological (anxiety, depression & trait anxiety) and cognitive processes (attentional disengagement [i.e. neutral body-irrelevant & threatening body-relevant performance on the MBT] and somatic distortion [change in false alarm rate on the SSDT]), and their relationship with health anxiety, symptom reporting and health care utilisation. The analysis therefore aimed to answer the following exploratory research questions:

6.1.1. *Research questions*

1. Does including attentional disengagement and somatic distortion, individually and together improve our understanding of symptom reporting, health anxiety and health care utilisation (i.e., model fit)?

2. Do symptom reporting and health anxiety act as mediators of the relationship between somatic distortion, psychopathology, biological factors and health care utilisation?

6.1.2. *Model specification*

Nine non-hierarchical models were evaluated with symptom reporting, health anxiety and health care utilisation as the dependent variables. Correlational relationships were specified between the dependent variables in models 1, 2, 3, 4, 5, and 6 in order to focus on the relationships between biological, psychological and cognitive factors. In models 1a, 3a and 4a, health care utilisation was taken as the dependent variable and symptom reporting and health anxiety were evaluated as possible mediators of the relationship between biological, psychological and cognitive factors and health care utilisation.

Model 1 (Figure 6.1 below), represents a basic somatisation model (e.g., Lipowski, 1988) where psychopathology (state anxiety, trait anxiety and depression) is associated with symptom reporting, health anxiety and health care utilisation independently of biological factors (age, gender and medical conditions). In order to reduce the complexity of the models, minimize the number of parameters and maximise the robustness of the findings, psychological factors were grouped together into one observed variable 'psychopathology' (details can be found in 6.2.2). In accordance with the primary care results, positive causal pathways were predicted from psychopathology and medical conditions to the dependent variables. Based on empirical evidence, positive causal

pathways were also predicted from age and gender to symptom reporting (e.g. Barsky et al., 2001) and health care utilisation (e.g. Ladwig et al., 2000). Neither gender nor age have been found to be associated with health anxiety in previous research nor in the present research, therefore causal pathways between these variables were not specified. The model therefore contained 24 free parameters.

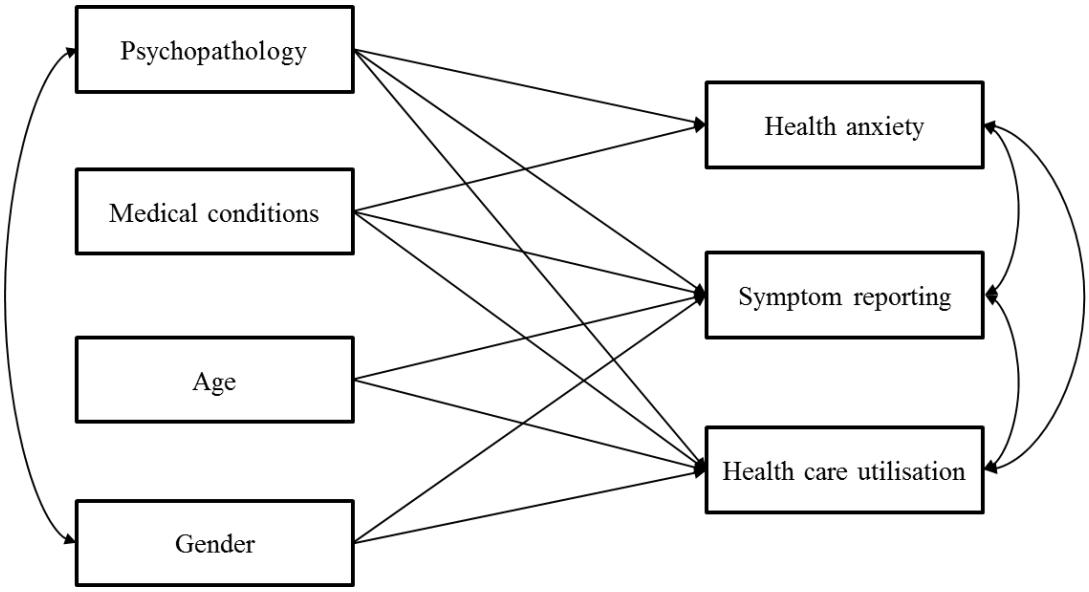

Figure 6.1 Basic model.

Model 1a (Figure 6.2 below), represents a mediated somatisation model where psychopathology predicts health anxiety and symptom reporting independently of biological factors. Health anxiety and symptom reporting mediate the relationship between psychopathological and biological factors and health care utilisation. This model hypothesises that health care utilisation is related to the experience of physical symptoms and health anxiety rather than being directly related to psychopathological or biological factors. These modifications to the basic model were justified as both health anxiety and symptom reporting were found to be independent longitudinal predictors of health care utilisation in Chapters 4 and 5. The basic mediation model contained a total of 23 free parameters.

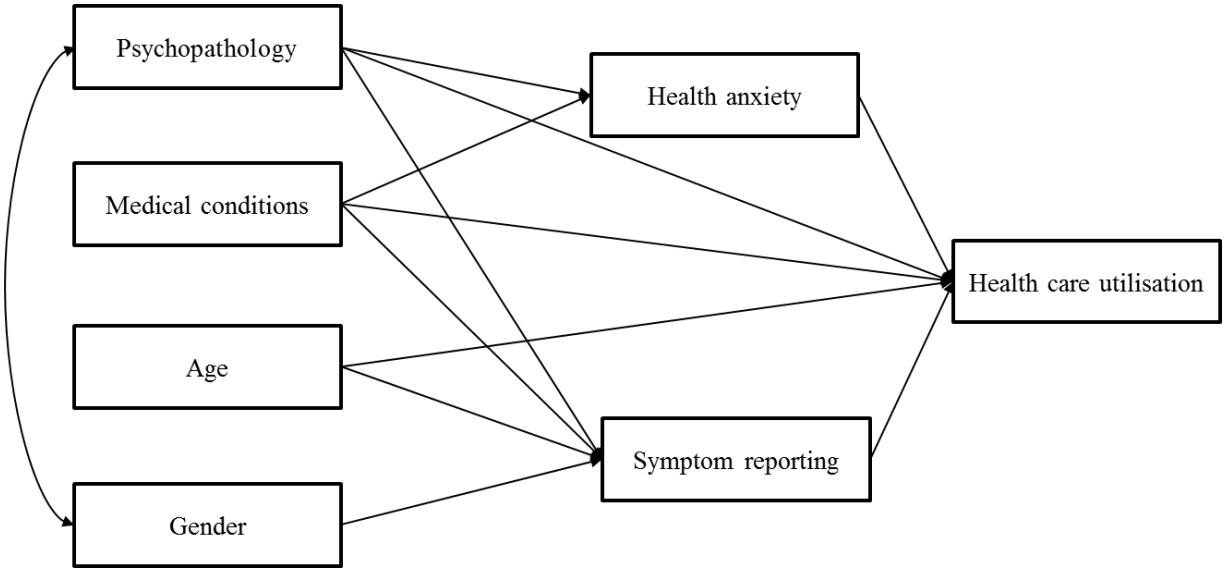

Figure 6.2 Basic model with mediation.

The theories of symptom perception, MUS and health anxiety discussed throughout this thesis all hypothesise that attention to the body is a key factor in the development and /or maintenance of physical symptoms, health anxiety and health care utilisation (e.g., Pennebaker, 1982; Barsky & Wyshak, 1990; Warwick & Salkovkis, 1990; Cioffi, 1991; Brown, 2004; Rief and Barsky, 2005; Edwards et al., 2012). These theories would all predict that the addition of variables measuring attention to the body (i.e., disengagement on the MBT) would improve the fit of the basic somatisation model to the outcome data. Model 2 (Figure 6.3) therefore represents an attentional model where, in addition to the relationships specified in model 1, visual performance in the neutral-scene and threat-body condition of the MBT were included as predictors.

Enhanced disengagement in the neutral-scene condition and delayed disengagement in the threat-body condition were both independently associated with health care utilisation and so positive and negative causal pathways were specified between these variables and health care utilisation. Age and medical conditions were also significant associated with performance and so positive causal pathways were specified between these variables. In accordance with the rationale outlined in Chapter 4, neutral-scene performance was included in the model to control for general task performance, thus a correlational relationship was specified between neutral-scene and threat-body performance. The model contained a total of 35 free parameters. As the performance variables were not found to be significantly related to symptom reporting or health anxiety in Chapter 4, relationships

between these variables were not specified and consequently a mediational analysis was not conducted.

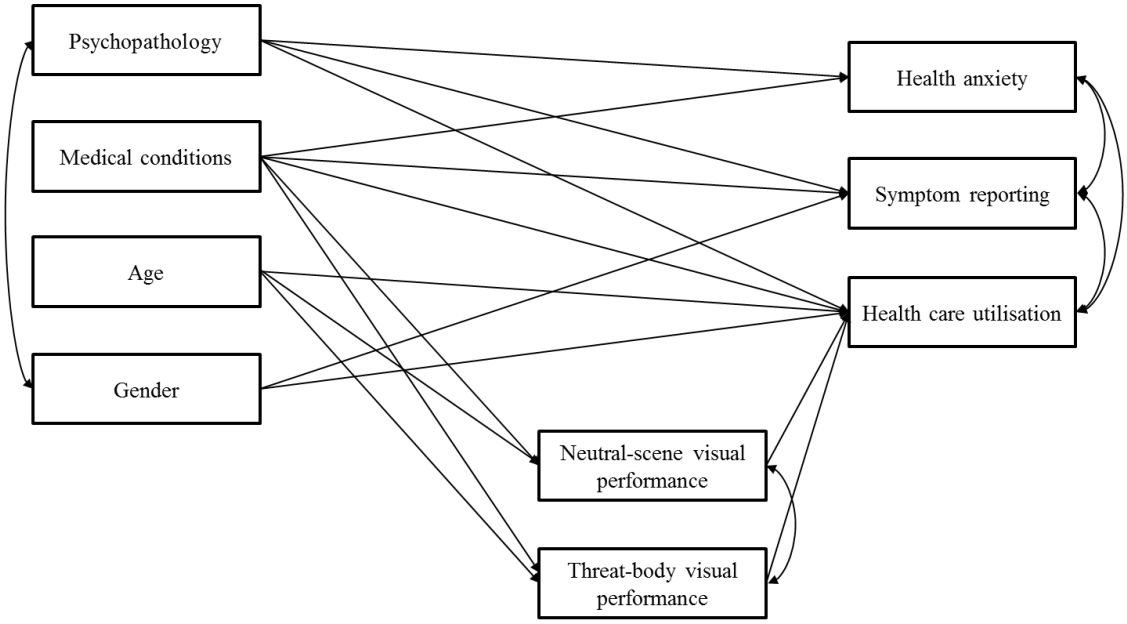

Figure 6.3 Attention model

Theories of symptom reporting, MUS and health anxiety (e.g., Pennebaker, 1982; Barsky & Wyshak, 1990; Warwick & Salkovkis, 1990; Cioffi, 1991, Brown, 2004; Edwards et al., 2012) all propose that specific biases in selective attention influence the contents, or interpretation of the contents, of somatic awareness. These theories would all predict that the addition of variables measuring the tendency to experience distortions in somatic awareness (i.e., false alarms on the SSDT) would improve the fit of a basic somatisation model to the outcome data.

Models 3 (Figure 6.4), 3a (Figure 6.6), 4 (Figure 6.5), and 4a (Figure 6.7), therefore represent somatic awareness models where, in addition to the relationships specified in Model 1, the tendency to experience somatic distortions was also included.

Model 3 included light-absent somatic distortions and Model 4 included light-present somatic distortions; both models contained a total of 31 free parameters. Both light-absent and light-present somatic distortion models were specified as they have both been found to have slightly different relationships with symptom reporting, health anxiety and health care utilisation, which we wished to further investigate using SEM analysis. Somatic distortion was found to be a positive predictor of symptom reporting, health anxiety and health care utilisation in the present research. Therefore positive causal pathways were specified from somatic distortion to the dependent variables.

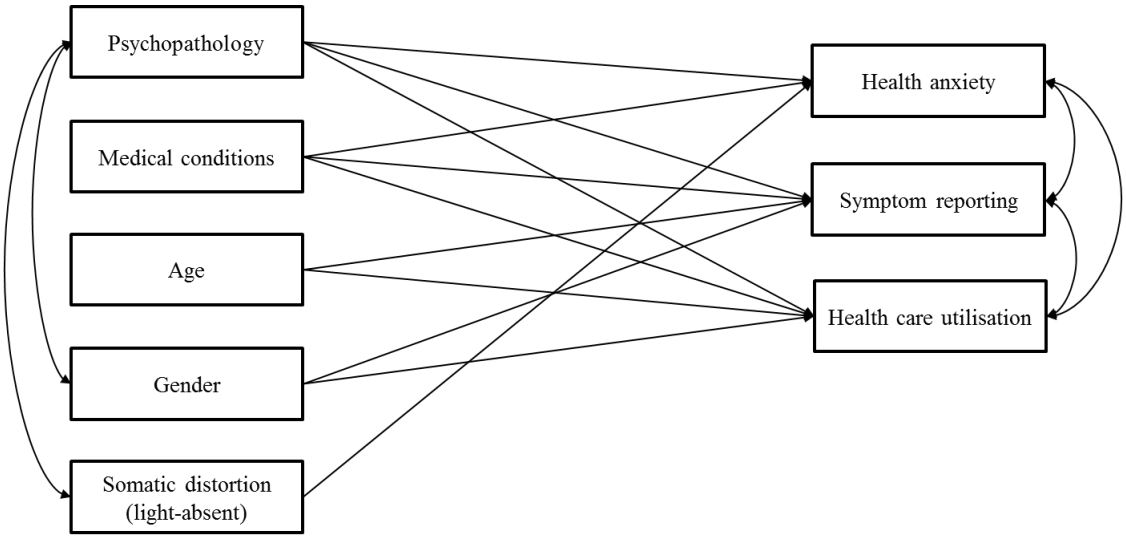

Figure 6.4 Somatic awareness (somatic distortion light-absent) model.

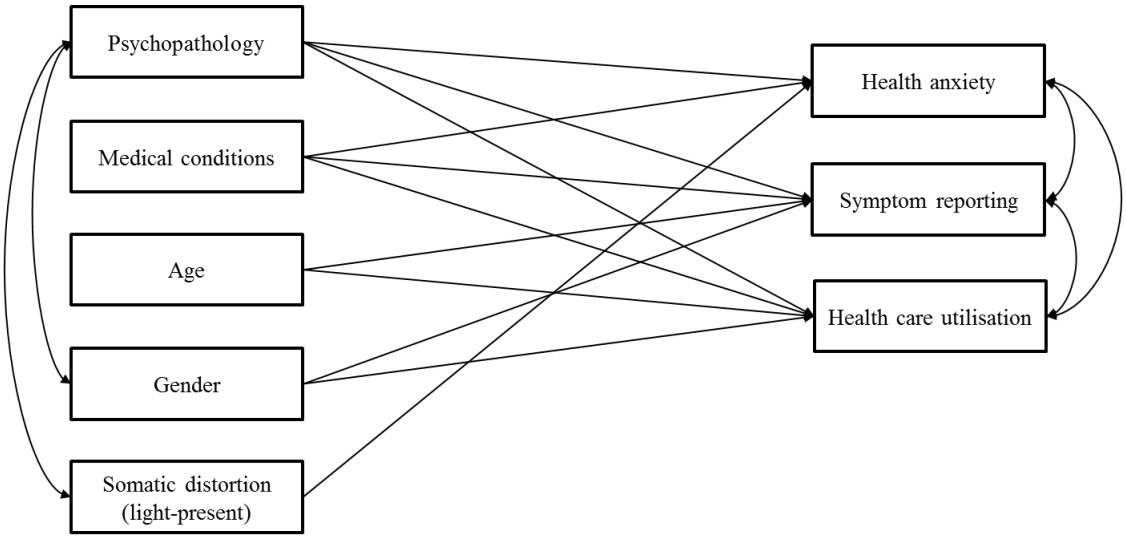

Figure 6.5 Somatic awareness (somatic distortion light-present) model.

Models 3a and 4a, represent mediated somatic distortion models where psychopathology and somatic distortion predict health anxiety and symptom reporting independently of biological factors. Health anxiety and symptom reporting mediate the relationship between biological factors, psychopathology, somatic distortion and health care utilisation. This model hypothesises that health care utilisation is related to the

experience of physical symptom and health anxiety rather than being directly related to somatic distortion, psychopathology or biological factors. Both models contained a total of 30 free parameters.

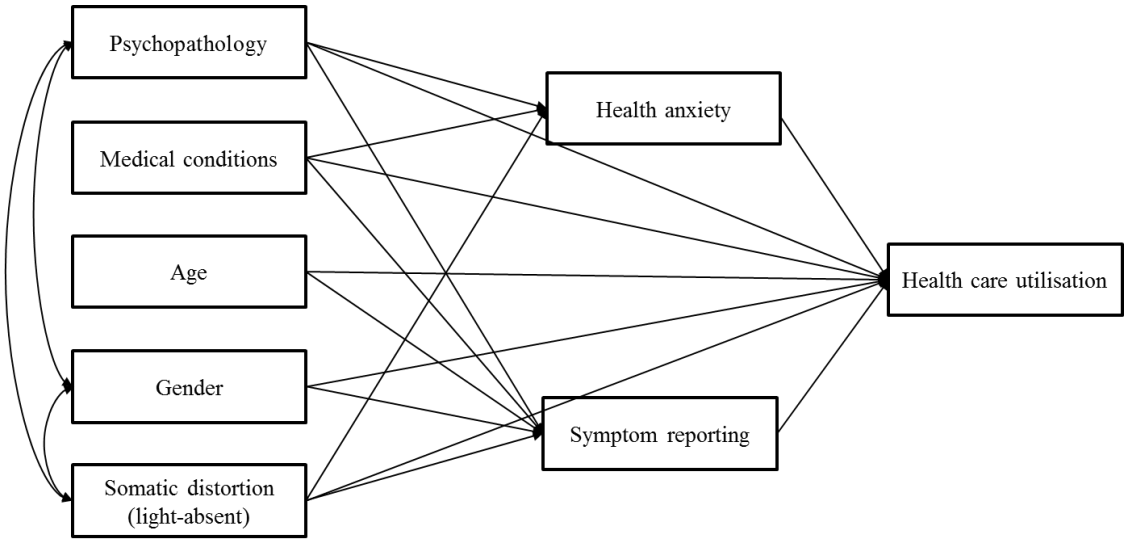

Figure 6.6 Somatic awareness (somatic distortion light-absent) mediation model.

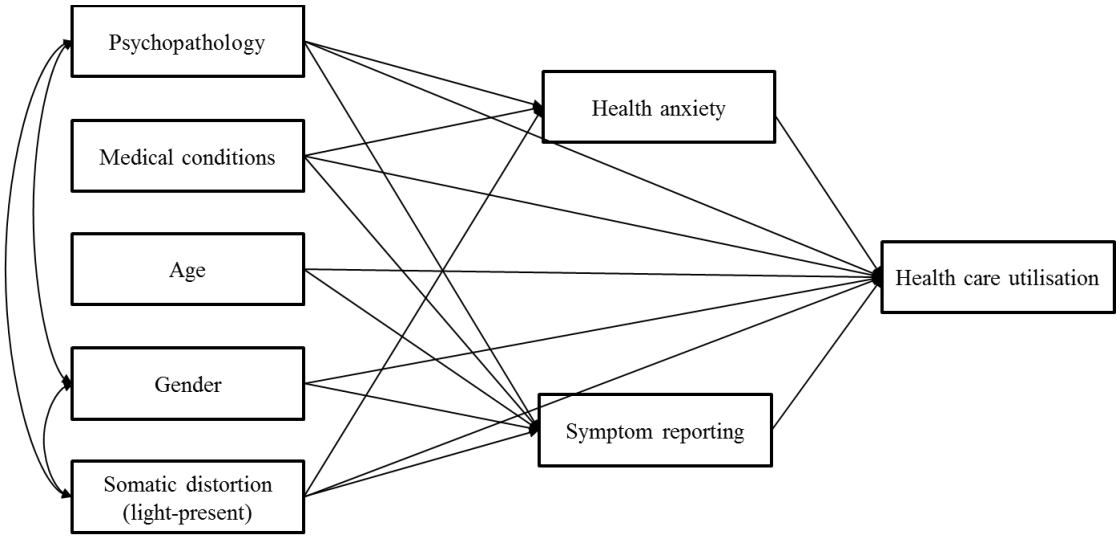

Figure 6.7 Somatic awareness (somatic distortion light-present) mediation model.

Theories of symptom reporting, MUS and health anxiety (e.g., Pennebaker, 1982; Barsky & Wyshak, 1990; Warwick & Salkovkis, 1990; Cioffi, 1991, Brown, 2004; Edwards et al., 2012) all propose that specific biases in selective attention influence the contents, or interpretation of the contents, of somatic awareness. These theories would all predict that the addition of variables measuring both attention to the body, that is, selective attention (i.e., disengagement on the MBT) and the tendency to experience distortions in

somatic awareness (i.e., false alarms on the SSDT) would improve the fit of a basic somatisation model to the outcome data.

Models 5 (Figure 6.8 below) and 6 (Figure 6.9 below) therefore represent combined models in which both attention and somatic awareness were included simultaneously as predictors within the basic somatisation model. Model 5 combined somatic distortion in light-absent trials, attentional disengagement, biological and psychopathologic predictors. Model 6 combined somatic distortion in light-present trials, attentional disengagement, biological and psychopathologic predictors. Both models contained 38 free parameters.

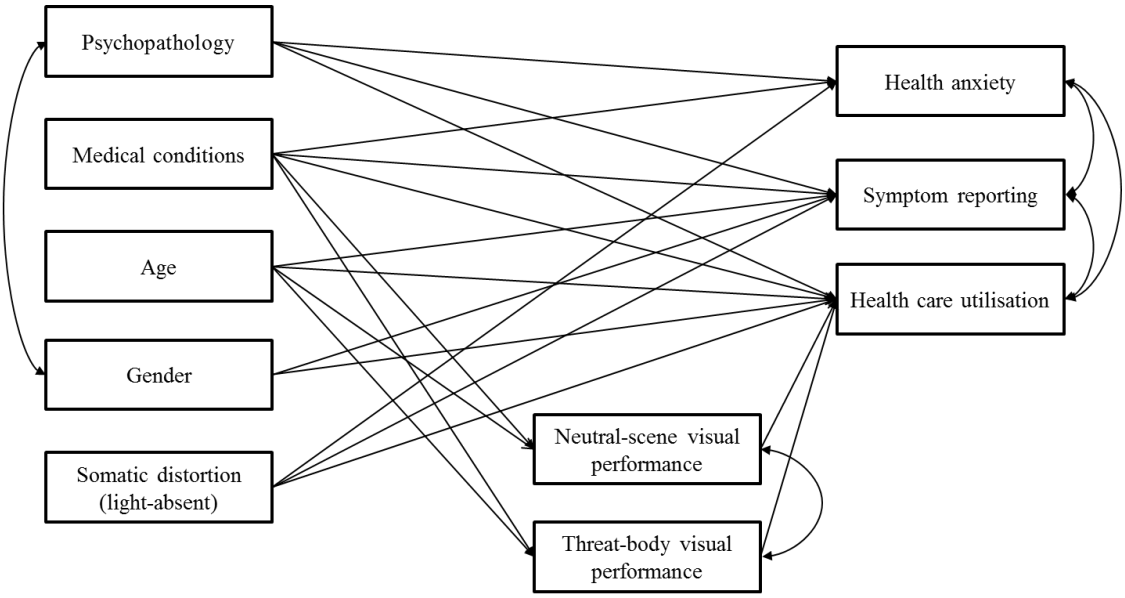

Figure 6.8 Combined (somatic distortion light-absent) model.

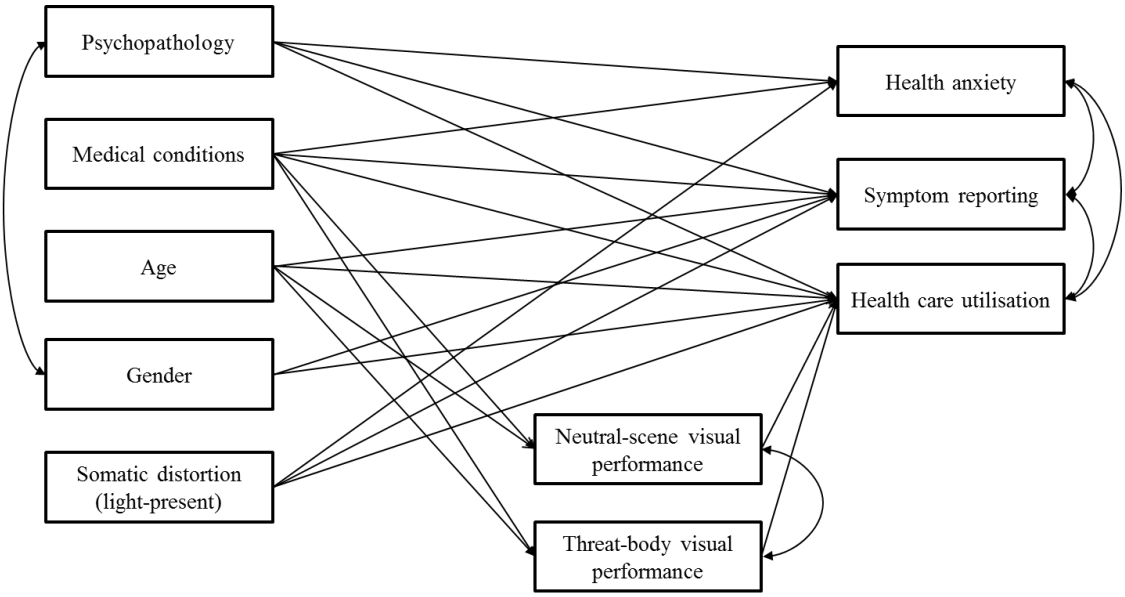

Figure 6.9 Combined (somatic distortion light-present) model.

6.2. Method

6.2.1. *Participants and procedure*

Participants were those recruited in the primary care study and the procedure was that undertaken in the primary care study (see Chapter 4 for full details of the participants and procedure). Recommendations regarding sample size when using SEM vary widely. It has been recommended that the minimum sample size should be greater than the minimum ratio of at least 5 participants for each estimated parameter (Bentler & Chou, 1987; Hair et al., 1998). In order to meet these requirements, data points from T1 and T2 were combined for each participant resulting in a sample size of 180. The estimated parameters in this study ranged from 23-38. Thus a sample size of 190 would meet the recommendations of Bentler and Chou for the maximum number of free parameters specified (38).

6.2.2. *Measures*

The following questionnaires and paradigms comprised the measurement models for the SEM analyses as represented in Figures 6.1-6.9. Dependent variables were: symptom reporting (PHQ-15), health anxiety (HAI) and health care utilisation (HCU). Predictor variables were: psychopathology ([BSI-A + BSI-D + STAI-T]/3), medical conditions (CCI), age and gender. Attentional disengagement was measured using both threat-body visual performance and neutral-scene visual performance in the same model. Somatic awareness was measured using light-absent and light-present false alarm change in separate models.

6.2.3. *Data analyses*

Data from 109 participants were screened for normality and the assumptions of multivariate analyses. Data from both T1 and T2 data points were combined for each participant resulting in 180 data points. The following data were found to be non-normally distributed at both T1 and T2: HAI, psychopathology, PHQ-15, HCU, light-absent false alarm change, light-present false alarm change, threatening body visual, neutral scene visual performance. Once both time points were combined, non-normal variables were transformed using log and square root transformations as appropriate, following the

recommendations of Tabachnick and Fiddell (1996). Gender and medical conditions were binary variables and were dealt with using constrained estimation. The multivariate distributions of all variables were found to be normal. Missing cases were missing at random (MAR). Therefore SEM parameters were estimated using full-information maximum likelihood (ML) estimation, where all available cases for each variable are analysed and cases with missing data points are not deleted or imputed. This method for incomplete data generally outperforms classical methods such as deletion or imputation (Arbuckle, 1996; Enders & Bandalos, 2001; Peters & Enders, 2002). All SEM analyses were conducted with Mplus (Version 7.11; Muthen & Muthen, 2011).

In accordance with the "causal steps approach" by Baron and Kenny (1986), two models were employed to evaluate potential mediation effects for the basic model and both somatic awareness models (light-absent and light-present false alarm change). An initial model was specified in which predictors had direct relationships with health anxiety, symptom reporting and health care utilisation. Secondly, a mediation model in which health anxiety and symptom reporting were mediators of the relationship between predictors and health care utilisation was specified.

Standardised estimates of pathways and their level of significance were calculated for each model so that direct comparisons could be made between variables. A 1 standard deviation (SD) change above the mean for the predictor variable resulted in the standardised estimate change from the mean of the dependent variable. For gender, a positive significant standardised value indicated that being female increased the dependent variable. Dashed pathways indicate non-significant relationships and the following code: * p <.05, ** p <.01, *** p <.001, was used to display statistical significance.

To assess the variance in the dependent variables explained by the predictor variables the R^2 statistic was calculated. To assess the fit of the model to the observed data and modelled covariance matrix, the chi-square statistic (χ^2) was calculated. A non-significant χ^2 statistic indicates good model fit because it means that the model-implied covariance matrix and the observed data matrix are not significantly different from one another. However, χ^2 is prone to type I errors particularly when sample size is small and correlations between variables are large; model fit in the present study was not, therefore, based solely on this statistic (Bentler & Bonett, 1980). To provide a comprehensive analysis of model fit the Tucker Lewis fit index (TLI), the route mean square error of approximation (RMSEA), and standard route mean square residual (SRMR) were also calculated (Kline, 2011). For the TLI, a score close to 1 indicates good model fit. The TLI

takes into account the number of model parameters and size of the correlations between measures, thus providing a comprehensive measure of model fit (Barrett, 2007). For the RMSEA, a score close to 0 indicates good model fit, cut-off points of 0.01, 0.05, and 0.08 indicate excellent, good and mediocre fit respectively (MacCallum, Browne & Sugawara, 1996). Confidence intervals (CI) were also calculated for the RMSEA; ideally the lower CI should be close to or include 0 and the upper CI should not be higher than 0.08. A CI in this range indicates that the RMSEA is accurate; CIs that deviate from this range indicate that the RMSEA is less accurate (Kenny, Kaniskan, & McCoach, 2011). For the SRMR, a value less than 0.08 is considered a good fit, however, there is no penalty for model complexity and as model complexity increases SRMR decreases (Hu & Bentler, 1999). In order to assess whether the addition of attention (neutral-scene performance and threat-body performance) and somatic awareness (light-absent and light-present somatic distortion, i.e. false alarm change) improved the fit of the model to the data, Akaike (AIC), Bayesian (BIC), and sample size adjusted Bayesian (adjusted BIC) information criteria were also calculated. Lower information criteria values indicate improved model fit.

6.3. Results

6.3.1. *Evaluation of the basic model (1)*

Figure 6.10 below displays a basic somatisation type model (1), which hypothesises that symptom reporting, health anxiety and health care utilisation are associated with psychopathology (state anxiety, trait anxiety and depression) independently of biological factors (age, gender and medical conditions). There were significant pathways from psychopathology and medical conditions to both health anxiety and symptom reporting. There were also significant pathways from age, gender and medical conditions to health care utilisation. Symptom reporting, health anxiety and heath care utilisation were all significantly associated with one another. There were near significant relationships between age, gender and symptom reporting as well as between gender and psychopathology (all *p*'s = .064-.077). The model explained a significant proportion of the variance in health anxiety (R^2 = .110, $p < .05$), symptom reporting (R^2 = .216, $p < .001$), and health care utilisation (R^2 = .117, $p < .01$). Model fit statistics for the basic model can be found in Table 6.1 below and all indicated the model fitted the data well. However, the

upper CI for the RMSEA was greater than 0.08, this suggests the RMSEA score may be a less accurate indicator of model fit in this case.

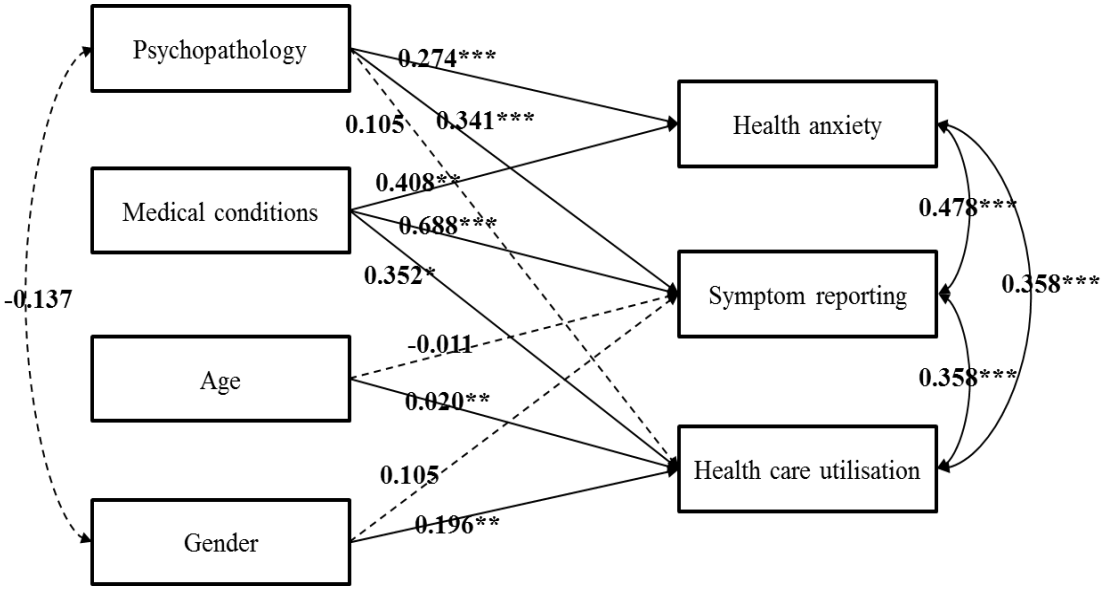

Figure 6.10 Basic model (1).

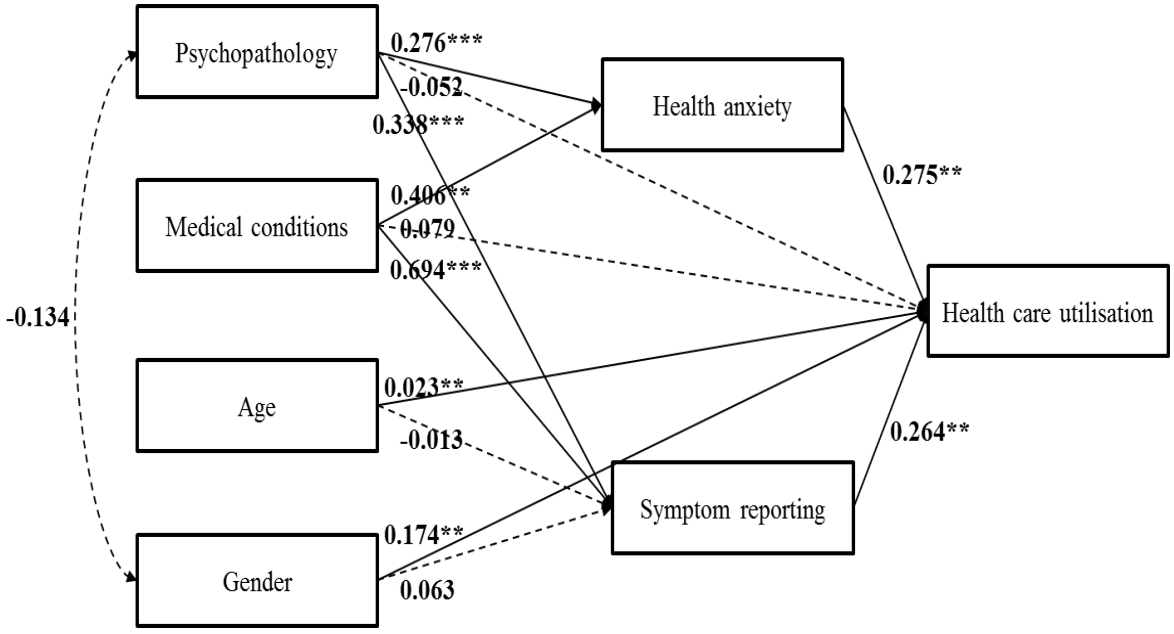

Figure 6.11 Basic model with mediation (1a).

Figure 6.11 above displays the basic mediated somatisation model. In this model psychopathology predicts health anxiety and symptom reporting independently of biological factors. Health anxiety and symptom reporting mediate the relationship between psychopathological and biological factors and health care utilisation. This model

hypothesises that health care utilisation is related to the experience of physical symptom and health anxiety rather than being directly related to psychopathological or biological factors.

Direct relationships between psychopathology, medical conditions and health care utilisation became non-significant, when health anxiety and symptom reporting were included as mediators. This indicates that both health anxiety and symptom reporting are mediators of the relationship between psychopathology, medical conditions and health care utilisation. Age and gender, however, maintained significant direct relationships with health care utilisation and had non-significant relationships with health anxiety and symptom reporting. This suggests that symptom reporting and health anxiety are not mediators of the relationship between age, gender and health care utilisation. The mediation model explained a significant proportion of the variance in health anxiety (R^2 = .110, $p < .05$), symptom reporting (R^2 = .214, $p < .001$), and health care utilisation (R^2 = .229, $p < .001$) and compared to Model 1, a greater proportion of the variance in health care utilisation was explained by this model. Model fit statistics for the model can be found in Table 6.1 below and all indicated that the basic mediation model was a poor fit of the data. This is likely due to the non-significant direct relationships included in the model.

Table 6.1 Model fit statistics for SEM models (1-6).

Model									
Index	1	1a	2	3	3a	4	4a	5	6
χ^2_M	9.83	55.64	23.66	10.51	52.83	11.79	54.93	31.68	27.19
DF_M	6	7	14	8	9	8	9	18	18
p	.13	.00	.05	.23	.00	.16	.00	.02	.08
RMSEA	0.06	0.20	0.06	0.04	0.16	0.05	0.17	0.07	0.05
(90% CI)	(0.00-0.12)	(0.15-0.25)	(0.00-0.10)	(0.00-0.10)	(0.12-0.21)	(0.00-0.11)	(0.13-0.21)	(0.02-0.10)	(0.00-0.09)
TLI	0.94	0.31	0.96	0.96	0.44	0.95	0.44	0.94	0.96
SRMR	0.05	0.08	0.05	0.04	0.07	0.05	0.08	0.05	0.05
AIC	1031.92	1075.73	-33.76	713.93	754.26	807.38	848.52	-46.70	-55.01
BIC	1108.55	1149.17	77.99	812.92	850.04	906.36	944.31	74.21	65.90
Adj. BIC	1032.54	1076.32	-32.86	714.74	755.03	808.19	849.30	-46.13	-54.44

6.3.2. *Evaluation of the attention model (2)*

Figure 6.12 below displays the attention model (2). Theories of symptom perception, MUS and health anxiety all hypothesise that attention to the body is a key factor in the development and/or maintenance of physical symptoms, health anxiety and health care utilisation (e.g., Barsky & Wyshak, 1990; Warwick & Salkovkis, 1990; Cioffi, 1991; Brown, 2004; Rief and Barsky, 2005; Edwards et al., 2012). These models would all predict that the addition of variables measuring attention to the body would improve the fit of the model to the outcome data (symptom reporting, health anxiety and health care utilisation). Model 2 (Figure 6.3) therefore represents an attentional model where, in addition to the relationships specified in model 1, visual performance in the neutral-scene and threat-body condition of the MBT were included as predictors. The attention variables were included to investigate whether their addition improved model fit.

Age and medical conditions were significantly associated with neutral-scene and threat-body visual performance. There were also independent relationships between age, medical conditions and health care utilisation. This indicated that neutral-scene and threat-

body performance were not mediators of the relationship between age, medical conditions and health care utilisation. There were significant pathways between neutral-scene performance, threat-body performance and health care utilisation. The pathway between neutral-scene performance and health care utilisation was negative and the pathway between threat-body performance and health care utilisation was positive. Both performance variables were significantly positively associated with one another. This pattern of relationships is identical to those found in Chapter 4, using multiple regression analysis. As neutral-scene disengagement only became a significant negative predictor in the presence of threat-body disengagement, these relationships were interpreted as a case of negative suppression. The SEM finding therefore provides further evidence that the suppressor effect is a robust and stable finding. The relationships established in the basic model (1) also remained significant. This indicates that the relationship between the attention variables and health care utilisation pertains to variance not explained by relationships between the other predictors and health care utilisation. The model explained a significant proportion of the variance in health anxiety ($R^2 = .110$, $p < .05$), symptom reporting ($R^2 = .216$, $p < .001$), and health care utilisation ($R^2 = .140$, $p < .01$). Model fit statistics for model 2 can be found in Table 6.1 and all indicated the model fitted the data well. However, the upper CI for the RMSEA was also greater than 0.080. The AIC, BIC and adjusted BIC were lower for Model 2 than for Model 1, suggesting that the addition of the attention variables improved the fit of the model to the data.

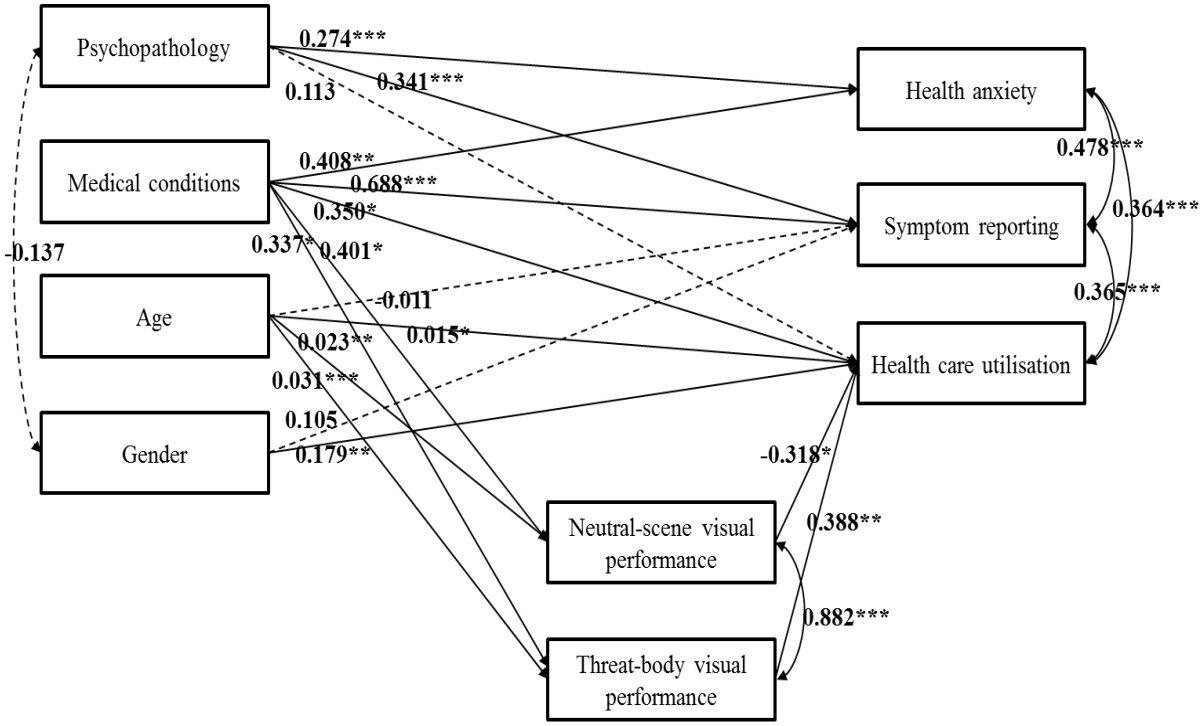

Figure 6.12 Attention model (2).

6.3.3. *Evaluation of the somatic awareness models (3; 3a; 4; 4a)*

Theories of symptom reporting, MUS and health anxiety (e.g., Pennebaker, 1982; Barsky & Wyshak, 1990; Warwick & Salkovkis, 1990; Cioffi, 1991, Brown, 2004; Edwards et al., 2012) all propose that specific biases in selective attention influence the contents, or interpretation of the contents, of somatic awareness. These theories would all predict that the addition of variables measuring the tendency to experience distortions in somatic awareness (i.e., false alarms on the SSDT) would improve the fit of a basic somatisation model to the outcome data.

In the light-absent model (3) the tendency to experience distortions in somatic awareness in light-absent trials was not significantly associated with psychopathology (p = .51) and the inclusion of this pathway did not attenuate the significant relationships between psychopathology, health anxiety and symptom reporting. This indicates that light-absent somatic distortion is not a mediator in the relationship between psychopathology, health anxiety or symptom reporting. There were significant relationships between light-absent somatic distortion, health anxiety, symptom reporting and health care utilisation. The independent relationships established in the basic model also remained significant with the exception of the relationship between age and symptom reporting, which was reduced to a near significant relationship (p = .075). This indicates that the relationship

between light-absent somatic distortion, health anxiety, symptom reporting and health care utilisation pertains to variance not explained by relationships between the other predictors. However, some of the variance between age and symptom reporting is shared by light-absent somatic distortion. Model fit statistics indicated that the model was a good fit of the data. In addition, the model explained a significant proportion of the variance in health anxiety (R^2 = .133, p < .01), symptom reporting (R^2 = .237, p < .01), and health care utilisation (R^2 = .140, p < .001). The AIC, BIC and adjusted BIC were lower for the present model compared to model 1, this suggests that model 3, is a better fit of the data than model 1.

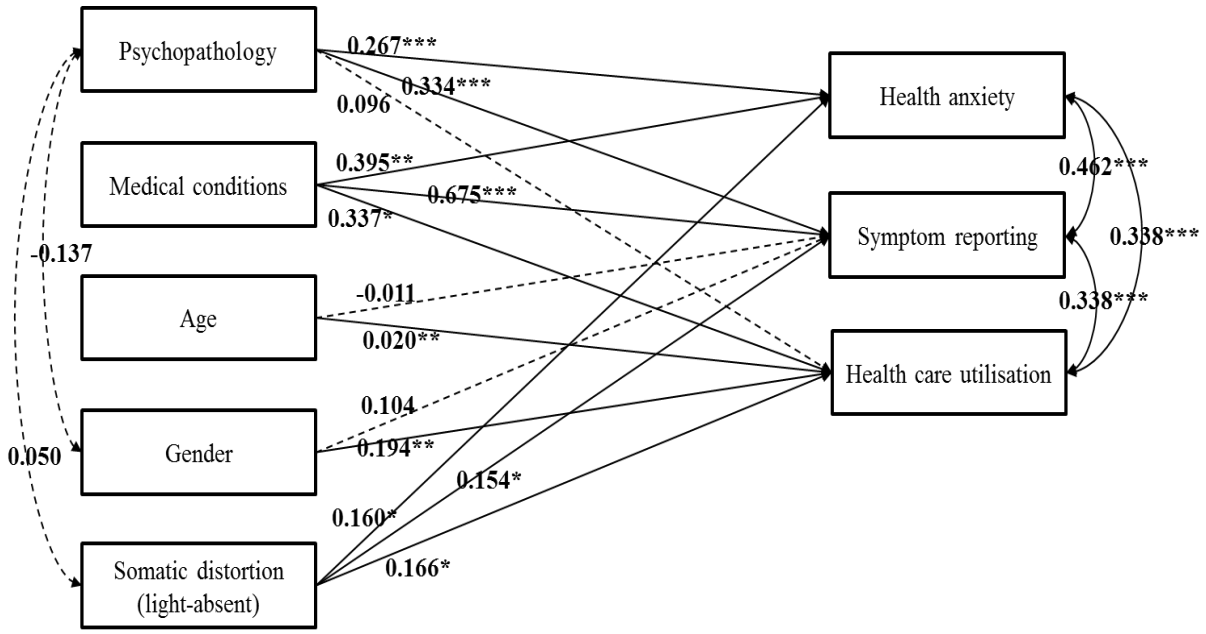

Figure 6.13 Somatic awareness light-absent model (3)

Figure 6.14 below displays the somatic awareness light-absent model with mediation (3a). This model hypothesises that health care utilisation is related to the experience of physical symptom and health anxiety rather than being directly related to somatic distortion, psychopathology or biological factors. The pattern of results observed for the basic mediation model (1a), were also observed for the light-absent somatic awareness mediation model (3a). In addition, the relationship between light-absent somatic distortion and health care utilisation became non-significant, whilst the relationships between light-absent somatic distortion, health anxiety and symptom reporting remained significant. This indicates that both health anxiety and symptom reporting are mediators of the relationship between light-absent somatic distortion and health care utilisation. The

model fit statistics indicated that the model was a relatively poor fit of the data; this is likely due to the non-significant relationships included in the model. The model explained a significant proportion of the variance in health anxiety (R^2 = .135, p < .01), symptom reporting (R^2 = .243, p < .001), and health care utilisation (R^2 = .234, p < .001). The AIC, BIC and adjusted BIC were lower for the present model compared to Model 1, suggesting that Model 3a is a better fit of the data than Model 1.

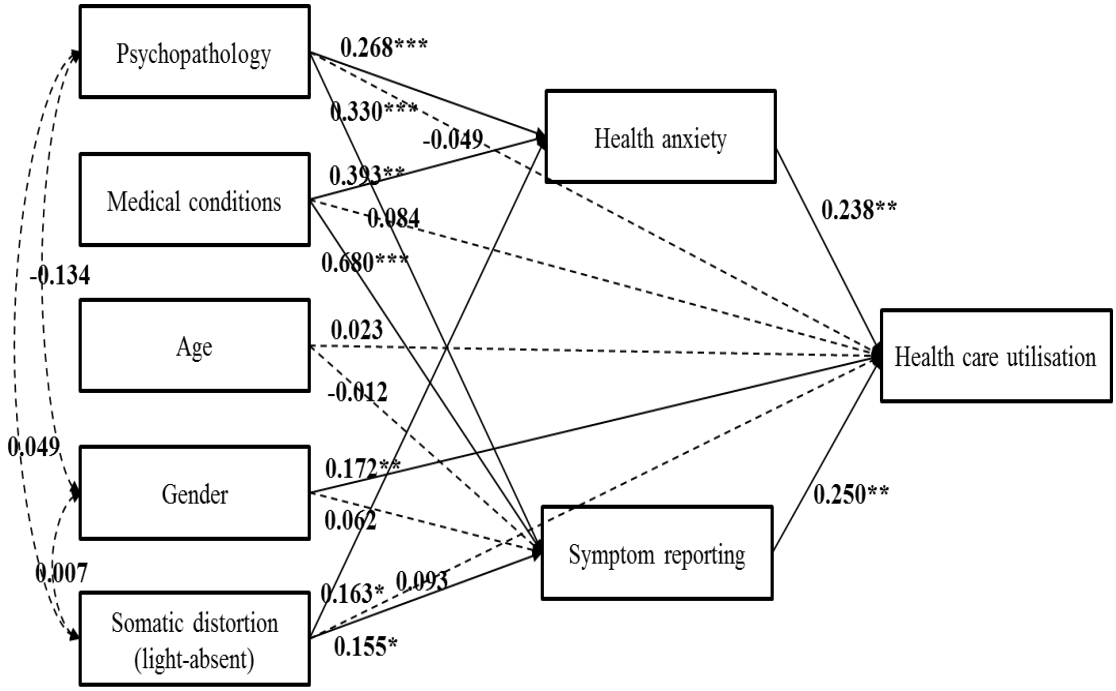

Figure 6.14 Somatic awareness light-absent model with mediation (3a)

Figure 6.15 below displays the somatic awareness light-present model (4). The tendency to experience somatic distortions in light-present trials was not significantly associated with psychopathology (p = .768) and the inclusion of this pathway did not attenuate the significant relationships between psychopathology, health anxiety and symptom reporting. This indicates that light-present somatic distortion is not a mediator in the relationship between psychopathology, health anxiety and symptom reporting. There was a highly significant relationship between light-present somatic distortion and health anxiety. In contrast to light-absent somatic distortions, the relationships between light-present somatic distortion, symptom reporting and health care utilisation were not significant. The independent relationships established in the basic model also remained significant, indicating that that the relationship between light-present somatic distortion and health anxiety pertains to variance not explained by psychopathology or medical

conditions. However, the relationship between age and symptom reporting was reduced to a near significant relationship (p = .071), indicating that part of the variance between age and symptom reporting is also shared by light-absent somatic distortion. Model fit statistics indicated that the model was a good fit of the data. The model explained a significant proportion of the variance in health anxiety (R^2 = .183, p < .01), symptom reporting (R^2 = .221, p < .001), and health care utilisation (R^2 = .117, p < .01). The AIC, BIC and adjusted BIC were lower for the present model compared to Model 1, and suggest that Model 4 is a better fit of the data than Model 1.

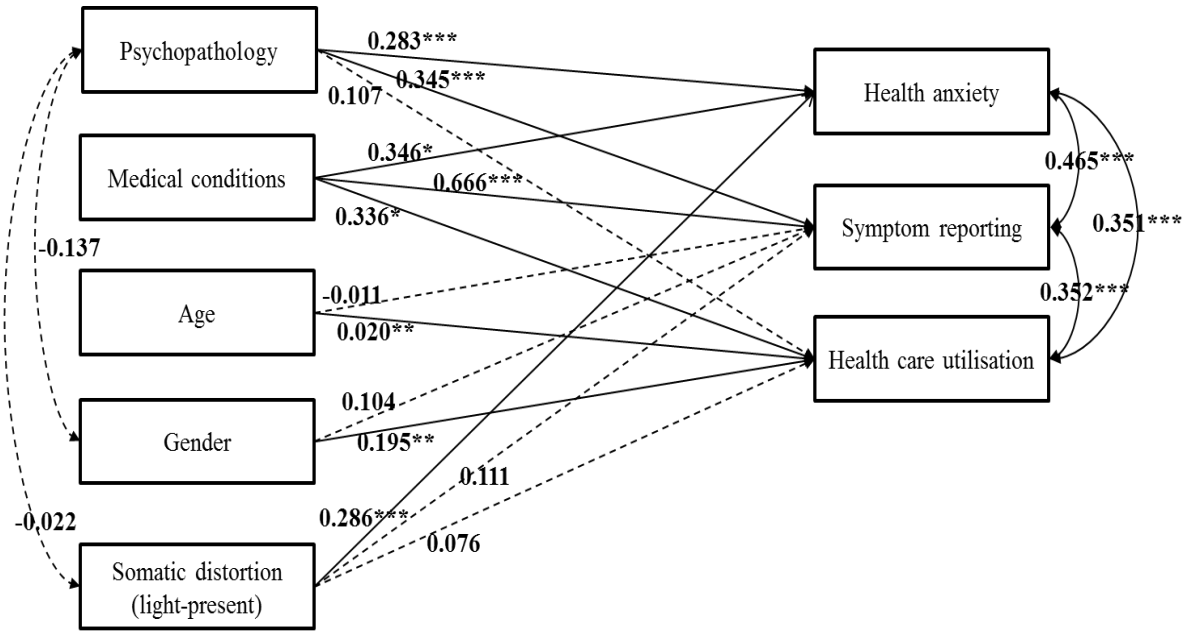

Figure 6.15 Somatic awareness light-present model (4)

Figure 6.16 below displays the somatic awareness light-present model with mediation (4a). This model hypothesises that health care utilisation is related to the experience of physical symptom and health anxiety rather than being directly related to somatic distortion, psychopathology or biological factors. The pattern of results observed for the basic mediation model (1a), were also observed for the somatic awareness mediation model (4a). Model fit statistics indicated that the model was a poor fit of the data, as with the other mediation models this is likely due to the high number of non-significant relationships included. The model explained a significant proportion of the variance in health anxiety (R^2 = .183, p < .01), symptom reporting (R^2 = .221, p < .001), and health care utilisation (R^2 = .117, p < .01). The AIC, BIC and adjusted BIC were

lower for the present model than for the basic model and suggest that the present model was a better fit of the data.

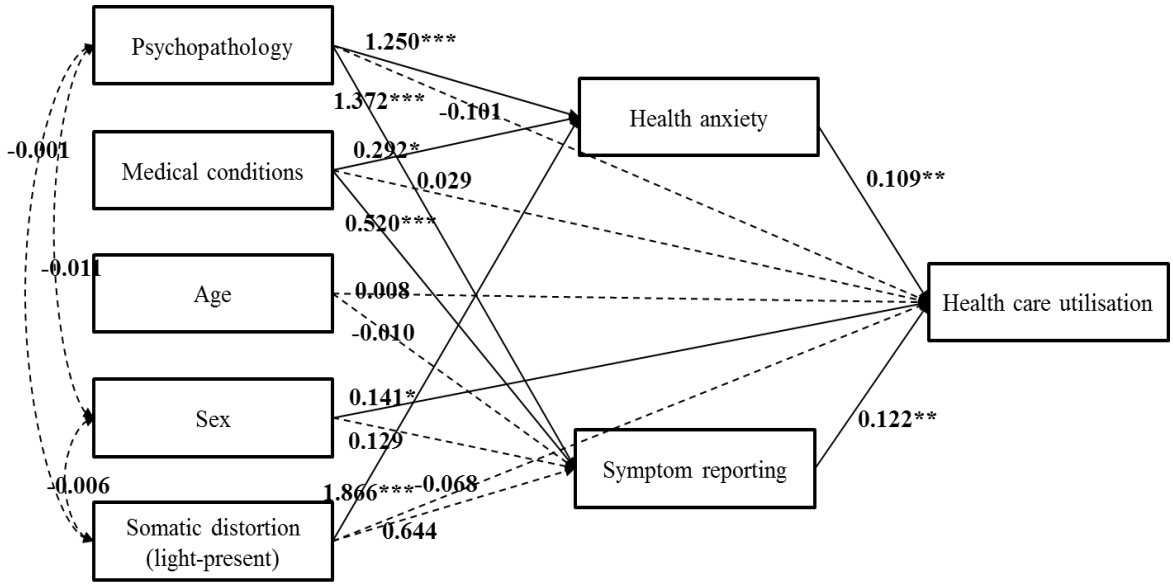

Figure 6.16 Somatic awareness model with mediation (4: light-present somatic distortion).

6.3.4. *Evaluation of the combined models*

Theories of symptom reporting, MUS and health anxiety (e.g., Pennebaker, 1982; Barsky & Wyshak, 1990; Warwick & Salkovkis, 1990; Cioffi, 1991, Brown, 2004; Edwards et al., 2012) would all predict that the addition of variables measuring both attention to the body, that is, selective attention (i.e., disengagement on the MBT) and the tendency to experience distortions in somatic awareness (i.e., false alarms on the SSDT) would improve the fit of a basic somatisation model to the outcome data.

Figure 6.17 below displays the first of two combined models; Model 5 includes both attention and light-absent somatic distortion and Model 6 (Figure 6.18) includes attention and light-present somatic distortion. The significant pathways established in the basic model, the attention model and the light-absent somatic distortion model all remained significant when predictors were combined together in one model. This indicates that light-absent and light-present somatic distortion and visual performance variables have independent relationships with health anxiety, symptom reporting and health care utilisation. However, the model fit statistics for Model 5 were equivocal. The χ^2 statistic was significant indicating the model was not a good fit of the data. However, the TLI was

close to 1, the RMSEA value was between 0.05 and 0.08 and the CI range for the RMSEA (0.078) was narrow which indicated the RMSEA index was accurate. The SRMR was also below 0.08 which also indicated the model was a good fit of the data. The model explained a significant proportion of the variance in health anxiety (R^2 = .138, p < .01), symptom reporting (R^2 = .236, p < .001), and health care utilisation (R^2 = .161, p < .01). The AIC, BIC and adjusted BIC were lower for the present model than for the basic model and somatic awareness models and were of a similar value to the attention model. Combined these statistics suggest that the combined model was a good fit of the data.

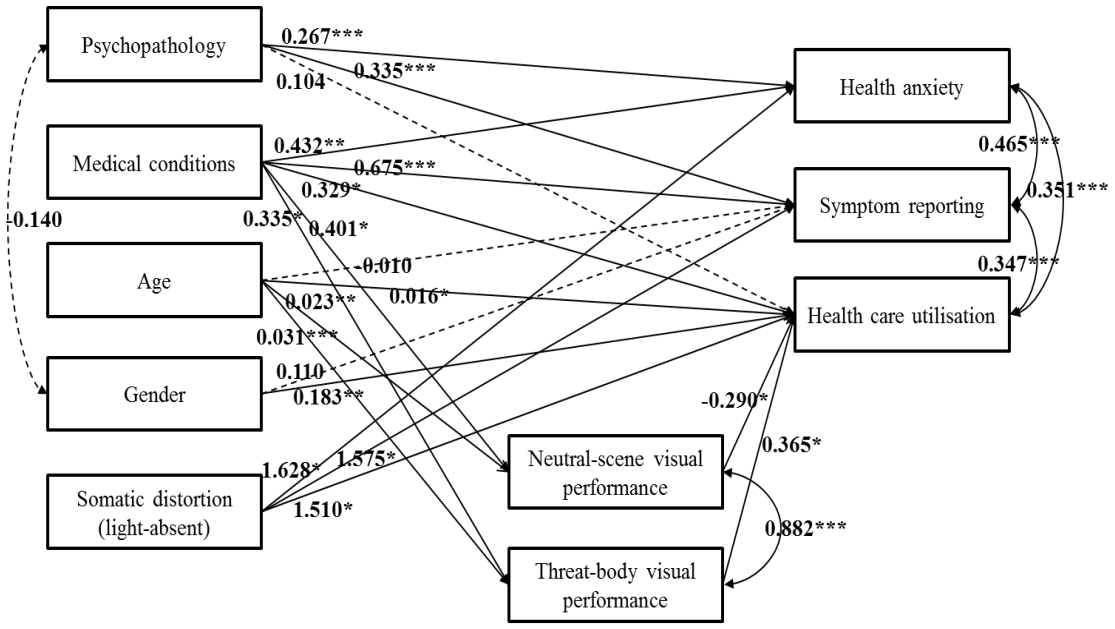

Figure 6.17 Combined model (5: light-absent somatic distortions and visual performance).

The model fit statistics for Model 6 indicated good model fit. The model explained a significant proportion of the variance in health anxiety (R^2 = .198, p < .001), symptom reporting (R^2 = .228, p < .001), and health care utilisation (R^2 = .153, p < .010). The AIC, BIC and adjusted BIC were, however, higher for the present model than for Model 5. These statistics suggest that although the χ^2 statistic for Model 5 was significant, and for the present model it was non-significant, Model 5 provided a better fit of the data than the present model.

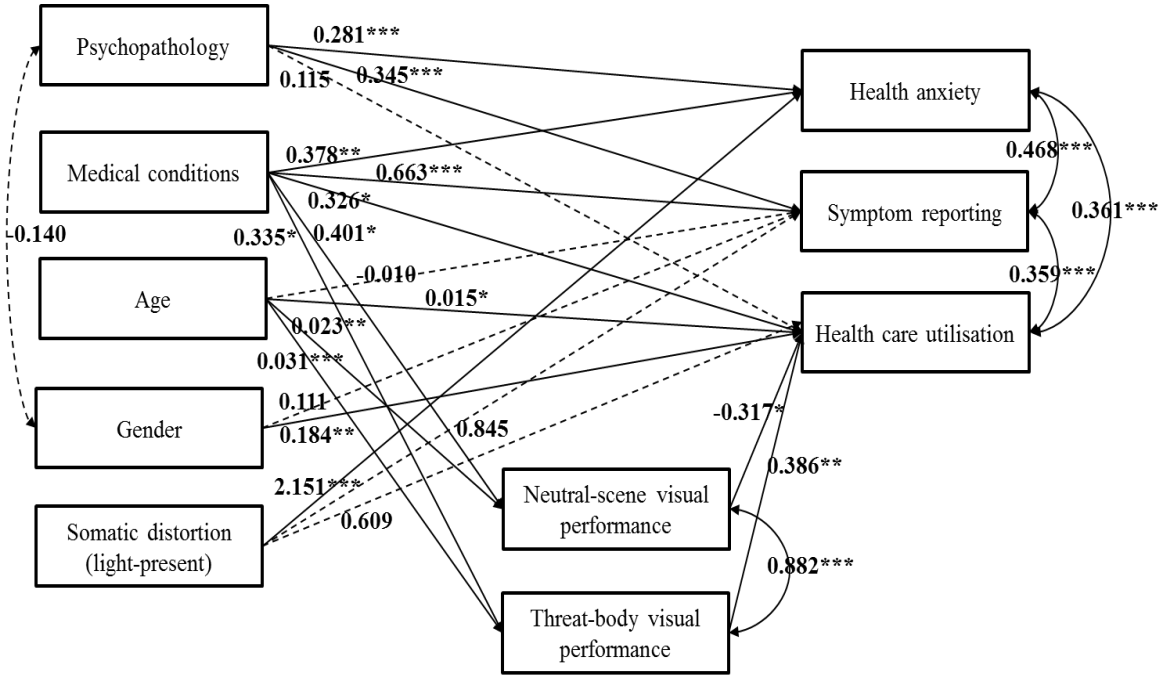

Figure 6.18 Combined model (6: light-present somatic distortions and visual performance).

6.4. Discussion

The general aims of the present chapter were to further support and extend the multiple regression analysis of the data collected in the primary care study. This chapter aimed to shed further light on the complex-interrelationships established in Chapter 4 and 5. More specifically, the aim was to investigate whether the addition of variables measuring attentional disengagement and somatic distortion improved understanding of symptom reporting, health anxiety and health care utilisation beyond that provided by the somatisation construct.

Epidemiological evidence suggests that women report greater numbers of physical and psychological symptoms than men (Barsky et al., 2001). Symptom reporting and age have also been associated with one another, with symptom reports peaking at around 55 years of age (Ladwig et al., 2000). However, the longitudinal analysis of the primary care study found that gender and age were not significant predictors of symptom reporting, but that they were significant predictors of health care utilisation. The SEM analyses further confirmed that both women and older participants have greater health care utilisation irrespective of other predictors. These findings were therefore unexpected and warrant further discussion.

The third most frequently prescribed medication in this sample was oral contraceptives. Thus, it might be reasonable to assume that routine appointments for women, related to reproductive health, may account for a significant proportion of health care utilisation. This may explain why the relationship between gender and health care utilisation was not mediated by symptom reporting. However, it is less clear why older people should have greater health care utilisation independently of medical conditions, symptom reporting and health anxiety. Older people may require more maintenance appointments which are not necessarily stimulated by either symptoms or health anxiety, such as, medication reviews. However, this would suggest the presence of medical conditions, such as, high blood pressure. The CCI, a self-report measure, was used to screen for the presence of medical conditions. However, the CCI does not provide an exhaustive list of all medical conditions. This may account for why the presence or absence of a medical condition was not a mediator of the relationship between age and health care utilisation. This suggests that the true relationship between medical conditions and other variables may not have been accurately evaluated. Therefore, future research may benefit from accessing patient records to determine the presence of diagnosed medical conditions.

The basic model can be considered to capture the somatisation construct, where a combination of biological factors and psychological distress lead to physical symptom reporting and health anxiety, which then lead to health care utilisation. The longitudinal analysis indicated that psychopathology was a unique predictor of health anxiety and symptom reporting but not health care utilisation; the SEM analysis confirmed these relationships. The longitudinal analysis also indicated that the presence of a medical condition was a unique predictor of symptom reporting, health anxiety and health care utilisation; the SEM analysis also confirmed this finding. Furthermore, the basic model with mediation suggests that health anxiety and symptom reporting are mediators of the relationship between medical conditions and health care utilisation, irrespective of the other predictors in the model. This suggests that reducing health anxiety in individuals with medically *explained* symptoms may reduce their health care utilisation.

Overall, the basic model was able to account for a significant proportion of the variance in health anxiety, symptom reporting and health care utilisation and was a good fit of the data. Theoretically, however, the basic model suggests that in the absence of a medical condition and psychological distress, health anxiety and symptom reporting scores above the mean would not exist. Furthermore, health care utilisation would be fully

explained by both age and gender. Since psychopathology and medical conditions did not account for 100% of the variance in symptom reporting, health anxiety or health care utilisation, the investigation of other relevant factors is clearly warranted. This further supports empirical evidence that indicates high symptom reporting may exist in the absence of psychological distress (e.g., functional somatisation; Kirmayer & Robbins, 1991).

The attention model confirmed the cross-sectional findings that both enhanced disengagement from neutral body-irrelevant material and delayed disengagement from threatening body-relevant material were independently associated with health care utilisation. Furthermore, the SEM analysis demonstrated that including variables measuring attentional disengagement led to an improvement in the fit of the model to the data, when compared to the basic model. Cognitive theories of MUS suggest that attention plays an important role in the development and maintenance of MUS. Generally theories suggest that those with MUS have a body-focused bias (Pennebaker, 1982; Barsky & Wyshak, 1990; Rief & Barsky, 2005), however, most have not specified how such a body-focused bias may manifest itself. The model of Brown (2004) has been more specific regarding the nature of attentional differences and suggests that those with MUS may have difficulties disengaging attention from symptom-relevant information. However, there is little empirical evidence to support these predictions. The findings of the primary care study and the SEM analyses provide some support for an association between hypervigilance for the body and poorer attentional disengagement from threatening body-relevant material and health care utilisation. However, a significant association was not found between attentional disengagement and symptom reporting or health anxiety. This finding is counter-intuitive and it is not clear why attention should be associated with health care utilisation independently of health anxiety and symptom reporting. Reasons why this may be the case were explored in detail in Chapter 4 and this finding certainly warrants further investigation.

The cross-sectional multiple regression analysis (see Chapter 5) indicated that the sustained tendency to experience somatic distortions in light-absent trials was an independently associated with symptom reporting and in light-present trials was associated with health anxiety. The SEM analysis further supported these findings, however, both light-absent somatic distortion and light-present somatic distortion were found to be associated with health anxiety. Furthermore, there was a significant independent assoxiation between light-absent distortion and health care utilisation. The results suggest

that the processes involved in light-present somatic distortions are associated with health anxiety, but not symptom reporting or health care utilisation, while the processes involved in light-absent distortions are associated with all three dependent variables.

The tendency to experience distortions (i.e. false alarm rate, rather than change in false alarm rate) in both light-absent and light-present trials have been found to be highly correlated with one another, (McKenzie et al., 2010) and involve similar brain regions (Lloyd, McKenzie, Brown, & Poliakoff, 2011). In the primary care study they were moderately correlated with one another (r range = .32-.41, $p < .05$). This suggests that similar processes may be responsible for both types of distortion. Individual differences in somatic distortion and response bias have been found to correlate between testing sessions spaced 1 week, 4 weeks (McKenzie et al., 2010) and, in the present research, 6 months apart, whereas individual hit rates and tactile sensitivity have not been found to be correlated between testing sessions in the present or previous research (McKenzie et al., 2010). This indicates a stable trait-like component for somatic distortion, which is influenced more by decision making processes (response bias) rather than perceptual sensitivity.

Somatic distortion tends to be greater in the presence of the light (e.g. Lloyd et al., 2008). A multisensory association between light and touch, reflecting typical correlations between multisensory events in everyday experience, may explain the increase in distortions in light-present trials (Johnson et al., 2006; McKenzie et al., 2011). It has also been suggested that the sometimes-observed increases in distortions in the presence of the light may reflect learning over the course of the task. However, both distortions and response bias have generally remained stable over the two test-halves. If such learning took place, distortions and response bias would be expected to increase over the two test-halves. Indeed, in the one study that did find a significant difference between the first and second test-half, distortions decreased on the second half which is counter to the idea that distortions reflect learning (Katzer et al., 2012). In the present study, it was also found that somatic distortion decreased in the second test-half.

Change in distortion rates across test halves has not been investigated as a predictor in previous studies. A decrease in distortion rates across test halves, in the absence of changes in hit rate or sensitivity, suggests that participants' overall judgement regarding the absence of the stimulus improved over the course of the task. However, in the second test-half, both light-absent and light-present distortions were both positively correlated with symptom reporting and health anxiety. This finding indicated that there

was change in the tendency to experience distortions in somatic awareness across the test-halves, which appeared to be related to symptom reporting and health anxiety. Therefore, change in somatic distortion in light-absent and present trials was investigated and found to be associated with health anxiety and symptom reporting.

In the present study, change in somatic distortion at T1 was not found to be correlated ($r = .09$, $p > .05$) between light-absent and light-present trials, but was found to be correlated at T2 ($r = .29$, $p < .05$). It is not clear why change in distortions should be correlated at T2 but not T1. However, slightly different processes to those hypothesised to operate in light-absent trials might underlie the often observed increase in distortion in light-present trials. Multi-sensory association is hypothesised to underlie the light-present increase in distortions. It is possible that changes across the task affect this multi-sensory association in a slightly different way to the processes considered to underlie light-absent distortions. That is, judgements regarding the likelihood of light and touch pairings may be affected in a slightly different way to judgements regarding the absence of a tactile stimulus across the task. It has also been observed that the light has stronger effects in some studies than others. Whilst this may be attributable to differences in experimental conditions between studies, such as the thresholding procedure and lighting levels, it is also possible that there are individual differences in the extent to which the presence of the light affects decision making regarding the presence or absence of an ambiguous tactile sensation (Katzer et al., 2012). This could explain why change in distortion in light-absent and light-present trials may be correlated in some cases and not others.

According to the Brown model, the tendency to experience distortions may indicate a generally lower activation threshold for somatosensory representations in memory (making it easier to elicit 'stimulus present responses'), which may be due to a reliance on top-down information rather than bottom-up information when assessing the presence of an ambiguous sensation. Distortions may also reflect a deficit in the ability to filter out sensory noise which is also considered to be a causative factor in the reporting of symptoms (Rief & Barsky, 2005). Brown et al. (2012) have suggested that these ideas may not be mutually exclusive. A filtering deficit could affect the reliability of somatosensory information as a source of information about bodily events. This may entail a greater reliance on top-down factors when generating somatic awareness. The findings of the SEM analysis, indicate that the sustained tendency to experience distortions across the task is an independently associated with symptom reporting, health anxiety and health care utilisation. This suggests that those who improve from block 1 to block 2 become more

able to monitor bottom-up (sensory) information accurately when making decisions about the presence or absence of a stimulus with practice on the task. It also suggests that those who remain the same or worsen may rely more on top-down information when making decisions and therefore do not show the same improvement. This could be due to a trait-like tendency to rely on top-down information (as hypothesised by the Brown model), because bottom-up information is unreliable due to deficits in the filtering system (as hypothesised by Rief & Barsky's model), or a combination of both.

Furthermore, the SEM analysis revealed that change in light-present distortion was an independently associated with health anxiety but not symptom reporting or health care utilisation. This indicates that health anxiety may also be associated with processes related to the pairing of multisensory events. Therefore those who, when presented with the visual stimulus (or experience a physical symptom) are more likely to activate top-down stimulus representations of the tactile stimulus (or other symptoms), or misattribute inert sensations (e.g. finger pulse or other bodily sensations) in a schema consistent way with the expected tactile stimulus (or other symptoms), may be at greater risk of developing health anxiety.

The SEM analysis has also demonstrated that including the sustained tendency to experience somatic distortion leads to an improvement in the overall fit of the model to the data, when compared with the basic somatisation model. Thus these findings further support biopsychosocial, cognitive-attentional and neurobiological model which all hypothesise alterations in somatic awareness to be related to symptom reporting and health anxiety.

A greater focus on current symptom experience and current health anxiety in relation to the tendency to experience somatic distortions, rather than retrospective reports, may shed further light on these complex relationships. At the very least, these findings suggest that further research is warranted.

Overall, the combined model (light-absent) and the attention model were the best fit of the data. Generally, the most parsimonious model would be the preferred model, which was the attention model. However, the combined model, which included both attentional disengagement and light-absent distortion, explained a greater proportion of the variance in symptom reporting, health anxiety and health care utilisation than the attention model. Therefore, this model may be selected and retained as the superior model (Kline, 2011).

6.4.1. *Strengths, limitations and future directions*

Employing a SEM approach to the analysis of the primary care data has allowed independent estimates of the complex inter-relationships between biological, psychological, and cognitive factors to be derived. Furthermore, model fit statistics have been used to determine the overall fit of *a priori* specified models to the data.

There are, however, several limitations to the present findings. There still remains a significant proportion of variance in health anxiety, symptom reporting and health care utilisation unaccounted for. Improving the measurement of variables may increase the amount of variance explained by the model. For example, a more accurate measure of medical conditions could be employed, such as one based on medical records. In addition, multiple measures could be used to determine latent variables such as attention, somatic awareness and psychopathology (Loehlin, 2004). This may improve the predictive power of the model, although a larger sample size would be necessary to test a model with latent, rather than observed variables (Kline, 2011).

The attention model and combined model (light-absent distortion) were established as superior models; there remain, however, other untested models. Such models may be equally or better fitted to the data and provide equally plausible explanations (Tomarken & Waller, 2005). The relationships investigated here were cross-sectional, therefore we are unable to make inferences regarding causality. The direction of causality between attention, somatic distortion, health anxiety, and symptom reporting has yet to be definitively established. Further research employing experimental designs is required.

There are also other variables which could have been investigated, such as, illness beliefs, acute illness and traumatic experiences. The aim of this study was not to provide a comprehensive account of all the factors that may influence symptom reporting, health anxiety and health care utilisation. Nevertheless, it is not known whether the relationships established in this analysis would be maintained in the presence of other known predictors. Finally, the sample size is not large enough to randomly split and cross-validate the analysis; replication in a larger sample is therefore necessary to validate the findings of this analysis.

In conclusion, this analysis has further supported and extended the multiple regression analysis employed in the primary care study. These findings add to a growing evidence base which suggests that the tendency to experience distortions in somatic awareness is associated with both symptom reporting (Brown, et al., 2010; Katzer et al.,

2011; Brown et al., 2012) and health anxiety (Katzer et al., 2013). In addition, it was found that somatic distortion was independently associated with health care utilisation. This analysis also supports the analysis of Chapter 4 which indicated that delayed disengagement from threatening body-relevant material and enhanced disengagement from neutral body-irrelevant material are associated with health care utilisation. Taken together, these findings provide support some support for biopsychosocial, cognitive-attentional and neurobiological models of symptom perception, MUS and health anxiety. Further experimental studies are required to establish causal relationships.

Chapter 7. Somatic awareness, attention and negative affect

7.1. Introduction

The present chapter describes the results of an analogue study carried out with participants recruited from the University of Manchester. The main aim of the research presented here was to investigate whether individual differences in attentional disengagement (as measured by the MBT) and somatic awareness (as measured by the SSDT) predict the development of physical symptoms following a negative event. In order to investigate this, participants completed a battery of questionnaires, the SSDT, the MBT and a negative mood induction. Evidence regarding the relationship between somatic awareness, attention, symptom reporting and negative emotional states is described briefly below.

7.1.1. *The effect of negative emotional states on symptom reporting*

Negative emotional states (e.g., fear, anger) are not only considered to be a consequence of the experience of physical symptoms; they have also been implicated as causative factors in their development and maintenance (Brown, 2004; Barsky & Wyshak, 1990; Cioffi, 1991; Rief & Barsky, 2005). Negative emotional states are thought to increase the likelihood of negative interpretations of ambiguous sensations, as well as increasing attention to the body or specific somatic experiences (Stegen, Van Diest, Van de Woestijne, & Van den Bergh, 2011; Wells & Matthews 1994; Gendolla, Anele, Andrei, Spurk & Richter, 2005).

The Rief and Barsky (2005) model suggests that those with deficits in their ability to filter out irrelevant somatosensory signals, and/or increased levels of attention to the body, may be more likely to develop physical symptoms. This filtering deficit is considered to be exacerbated by negative emotional states.

The Brown (2004) model suggests that negative affect may directly influence the encoding, storage and selection of rogue symptom representations. In this model, negative emotional states are thought to contribute to the chronic selection of rogue symptom representations, and may explain why symptoms often arise following acute stressors. Negative emotional states are hypothesised to activate rogue symptom representations in two ways. Firstly, they may increase symptom-focused attention which lowers the activation threshold of rogue symptom representations. Secondly, negative emotional

states may result in a narrowing of attention which also decreases the activation level of rogue representations. The Brown model would therefore predict that individuals who have a tendency to experience distortions in somatic awareness and/or increased levels of symptom-focused attention may be more likely to develop physical symptoms following a negative event.

7.1.2. *Study aims and hypotheses*

The main aim of the present study was to test hypotheses derived from the models of Brown (2004) and Rief and Barsky (2005), by investigating whether individual differences in the tendency to experience somatic distortions (FAs), deficits in sensory filtering (more sensitive tactile thresholds) and attentional disengagement (MBT performance) predict the development of physical symptoms following a negative event (negative mood induction). We also wished to investigate whether individual differences in emotional responses to a negative event (i.e., negative mood induction) predict the development of physical symptoms following the event.

The results of Chapter 4 indicate that enhanced visual disengagement in the neutral body-irrelevant condition and delayed visual disengagement in the threatening body-relevant condition predict health care utilisation. The results of Chapter 5 suggest that the tendency to experience distortions in somatic awareness is independently associated with symptom reporting, but tactile threshold was not. Previous research has found clinical high symptom reporting to be associated with more sensitive tactile thresholds (Katzer et al., 2013). Therefore the primary study hypotheses were that the tendency to experience somatic distortions, more sensitive tactile thresholds, enhanced attentional disengagement in the neutral body-irrelevant condition, delayed attentional disengagement in the threatening body-relevant condition, and lower mood following a negative mood induction will (a) predict the development of physical symptoms following a negative mood induction; and (b) that these relationships will remain when additional covariates (e.g. age, gender, health anxiety, trait anxiety, anxiety, depression, pre- induction mood and physical symptoms) are controlled for.

The second aim was to investigate whether attentional disengagement (MBT performance) and somatic awareness (somatic distortion [FAs] and tactile threshold) were associated with retrospective symptom reporting and retrospective health anxiety. The secondary study hypotheses were as follows: both (i) attentional disengagement and

somatic distortion will be positively associated with retrospective symptom reporting and health anxiety; (ii) tactile threshold will be negatively associated with symptom reporting and health anxiety; and (iii) these relationships will remain when controlling for relevant covariates.

7.2. Method

7.2.1. *Participants*

107 students and staff of the University of Manchester (86 female; median age 19.05 years; age range 18.01-28.01; 99 right-handed) took part in the study in return for course credits or for shopping vouchers (£10). The study was approved by the University Research Ethics Committee. All participants gave written informed consent prior to participation. All participants had normal (or corrected-to-normal) vision, and none reported any sensory deficits.

7.2.2. *Materials*

Questionnaires. The EHI (Oldfield, 1968), PHQ-15 (Kroenke et al., 2002), HAI-S (Salkovkis et al., 2002), STAI-T (Spielberger, Gorush, & Lushene, 1970), GAD-7 (Spitzer et al., 2001) and PHQ-9 (Kroenke et al., 2001) were completed by participants. In addition to these questionnaires, three visual analogue scales were completed pre- and post- the MBT and negative mood induction in order to measure current mood state. Participants were asked to rate how they were feeling 'at the present moment' from 0 (not at all) to 10 (extremely) for 'anxious', 'depressed' and 'disgust'. These ratings were combined to form total mood rating scores ranging from 0-30. A modified version of the symptom checklist (SCL; Pennebaker, 1982), incorporating two further symptom components common in primary care ('pain' and 'fatigue'; Kirkwood et al., 1982) was used to measure current symptom experience. Participants rated present-moment experience of all 14 symptoms on visual analogue scales ranging from 0 (no symptom) to 6 (experiencing symptom). Items were summed yielding an overall score ranging from 0-84.

Experimental tasks. Participants completed both the SSDT and MBT; for a full description of both tasks see Chapter 3, Section 3.3.

Mood manipulation. The negative mood induction was an eleven minute video of scenes taken from the BBC One TV medical drama "Casualty". The video contained

fictional scenes depicting emotional distress, bodily harm, traumatic injury, blood, death and invasive medical procedures including injections and cutting through tissue. To ensure that participants were attending to the video, red digits were presented on-screen at three separate points in the video. Participants were required to say the digits out loud and their responses were recorded. The correct response rate was 100%, indicating that all participants were attending to the video.

7.2.3. *Overall study design and procedure*

A within-subjects design was employed to increase power, and to reduce error variance. Previous research has demonstrated that the relationship between somatic distortion, attention and symptom reporting tends to yield a small-medium effect size. Therefore employing a within-subjects design would ensure sufficient power to detect such an effect. Furthermore, there are many unmeasured factors that could influence relationships between pre- mood induction performance on the MBT and SSDT and post-induction symptom experience. Using a within-subjects design reduces the likelihood that any relationship between the variables of interest is due to unmeasured individual differences.

A neutral mood condition was not employed in the present study as a control condition. Instead a manipulation check was performed and pre-induction mood and symptoms were controlled for in the analysis. However, as a neutral condition was not employed it is not possible to definitively rule out that any significant increase in post-induction symptom experience or negative mood was not a consequence of fatigue or boredom rather than the mood manipulation itself.

The study was advertised to staff and students via posters, and an experimental credit system. Figure 7.1 below details the design and procedure of the two part study. In part one, participants completed an online consent procedure, followed by a battery of online questionnaires (PHQ-15, HAI, STAI-T, PHQ-9 & GAD-7), and booked a follow-up research appointment. In part two, participants attended a research appointment lasting approximately two hours. At the beginning of the research appointment a brief overview of the study and an opportunity to ask questions was provided. However, participants were not informed about the study objectives until completion. To ensure the set-up of the SSDT was appropriate (which required the use of the index finger of the non-dominant hand to detect tactile pulses), handedness was first determined using the EHI. Participants

completed the SSDT first so that their tactile detection threshold was not affected by receiving the supraliminal vibrations given in the MBT. They then completed the state mood measures and modified SCL, followed by the MBT, and repeated the state mood measures and modified SCL. Participants were then provided with a 10 minute break in which they were offered magazines and light refreshment. After the break, they completed the state mood measure and modified SCL, watched the negative mood induction and repeated the state mood measure and modified SCL for the final time.

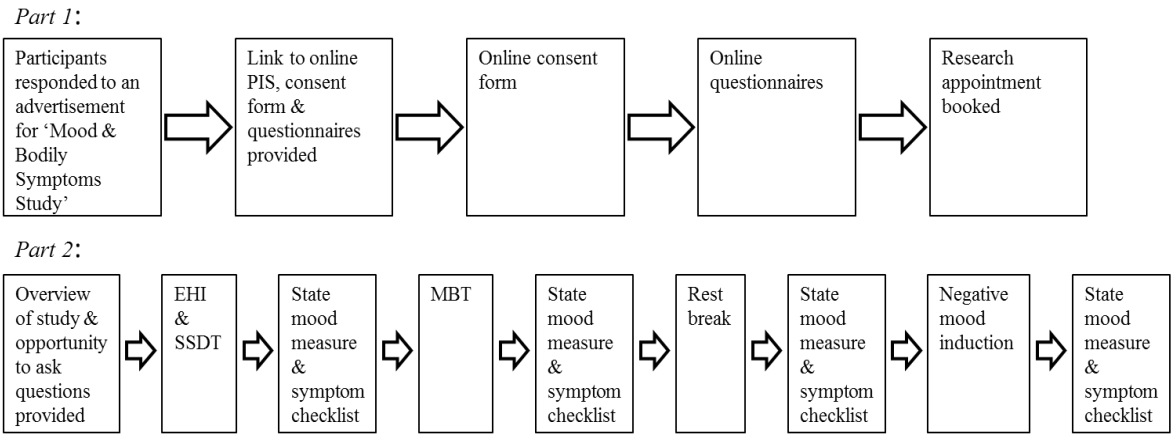

Figure 7.1 Design and procedure of the two part study.

7.3. Statistical analysis

7.3.1. *Data preparation*

Although 107 participants were tested, data from 106 participants were included in the final MBT sample because the equipment failed during the testing of one participant. Data from all 107 participants were included in the SSDT sample; however, due to time constraints, only 69 participants completed the post- SSDT threshold measure. The post-SSDT threshold measure was not a main outcome measure of this study, but was used to establish the reliability of the threshold procedure. Because of the missing data from the post- SSDT threshold measurement, the pre- SSDT threshold measure was used for the purposes of analysis. Prior to analysis, data from the MBT were prepared using the same outlier removal procedure as detailed in Chapter 3 (Section 3.4.1); this resulted in the removal of 4.9% of trials. Tactile and visual performance (inverse efficiency) in each picture condition was calculated in the same way as detailed in Chapter 3 (Section 3.4.1);

the tactile bias measure, however, was not calculated. The SSDT data were prepared using the same procedure as detailed in Chapter 3 (Section 3.4.1).

7.3.2. *Data distribution*

Both questionnaire and task data were screened for normality. Non-normal variables (see Appendix E, Section E.1 for full details) were transformed using log and square root transformations as appropriate, following the recommendations of Tabachnick and Fiddell (1996). The following variables were non-normally distributed and could not be transformed (Age; gender; PHQ-9; GAD-7; all picture threat ratings; post- MBT mood: pre- induction mood & symptoms; post- induction mood; post- SSDT tactile threshold; Hit rate & FA rate in both blocks and light conditions). Non-parametric tests were used in the analysis of these variables, where appropriate.

7.3.3. *Analyses addressing study aims and hypotheses*

Preliminary analyses. Prior to testing the main hypotheses the reliability of the measures was established (Cronbach's α) and group characteristics were explored with descriptive statistics. A manipulation check was performed on the subjective threat ratings of the pictures employed in the MBT using Wilcoxon matched-pairs tests. Repeated measures ANOVAs were used to analyse the effect of the picture cues on MBT performance. To establish the validity and reliability of the SSDT computerised threshold procedure the following analyses were performed. Block 1, light-absent, hit rates were screened to establish whether participant performance was in the 40-60% range expected. Test-retest correlations and tests of difference were conducted between the pre- and post-tactile threshold measurements. To establish whether SSDT performance was comparable to previous studies, tests of difference were conducted between block 1 and 2 and between light conditions for: hit rate, false alarm rate, response criterion (*c*) and tactile sensitivity (*d*'). A manipulation check was performed on the mood and symptom ratings pre- and post- MBT and negative mood induction using Wilcoxon matched-pairs tests.

Primary analyses. In order to evaluate the primary study hypotheses, correlations were conducted between visual and tactile performance (neutral-scene & threat-body conditions), false alarms (block 1 & 2; light-absent & light-present) and post mood-induction symptom experience. Hierarchical multiple regressions, controlling for relevant covariates, were conducted to evaluate whether change in mood following the mood

induction (post-induction mood total minus pre-induction mood total), MBT performance (visual & tactile performance in the threat-body condition; additionally controlling for neutral-scene performance), and SSDT performance (FAs) were predictive of post-induction symptom experience.

Secondary analyses. In order to address the secondary study hypotheses, correlations were conducted between task performance (MBT & SSDT), symptom reporting and health anxiety. Hierarchical multiple regressions, controlling for relevant covariates (e.g. age, gender, STAI-T, PHQ-9, GAD-7), were conducted to evaluate whether MBT and SSDT performance were independently associated with symptom reporting and health anxiety. Total PHQ-15 and total HAI were the target variables; MBT performance was analysed for each picture condition separately and FAs on the SSDT were analysed for each block and light condition separately. In the analysis focusing on symptom reporting, health anxiety was included as an additional covariate and in the analysis focusing on health anxiety, symptom reporting was included as an additional covariate.

Overall. Two-tailed tests of significance are reported throughout, an alpha level of .05 was used, and measures of effect size are all Pearson's *r*, or for non-parametric correlations Spearman's *r; r*≥.10 was considered a small, *r*≥.30 a medium, and *r*≥.50 a large effect. All statistical analyses were conducted using SPSS version 20.0 (IBM SPSS Inc., Chicago, IL).

7.4. Results

7.4.1. *Preliminary analyses*

Sample characteristics

Table 7.1 below displays descriptive statistics for un-transformed questionnaire measures. Cronbach's α indicated that the reliability of the measures was high to very high (α range = .73 - .91). A total of 24 participants reported clinically relevant levels of symptom reporting (PHQ-15 scores > 10; Körber et al., 2011), and 23 participants reported clinically relevant levels of health anxiety (HAI scores > 18; Salkovskis et al., 2002). However, the range for symptom reporting was limited, with the maximum symptom score being 16 out of a possible 30.

Table 7.1 Median (IQR), Cronbach's α, range and possible range for un-transformed questionnaire measures (n = 107)

Questionnaire	Median (IQR)	Cronbach's α	Range	Possible range
PHQ-15	7.00 (6)	.73	0-16	0-30
HAI	14.00 (8)	.89	0-39	0-54
STAI-T	41.00 (13)	.91	25-70	20-80
GAD-7	4.00 (5)	.87	0-15	0-21
PHQ-9	4.00 (6)	.87	0-20	0-27

Is the MBT threat manipulation effective?

The median subjective threat ratings for the picture stimuli were: neutral-scene, 0.00; neutral-body, 0.38; threat-scene, 6.68; threat-body, 6.00. Tests of difference revealed that threatening pictures were rated as significantly more threatening than neutral pictures (scene: z = -8.85, p < .001, r = .86; body: z = -8.90, p <.001, r = .86); these differences yielded large effect sizes and indicate that the manipulation was effective. Neutral-body pictures were rated as significantly more threatening than neutral-scene pictures (z = -4.49, p = .00, r = .44), with a medium effect size. Threat-scene pictures were rated as significantly more threatening than threat-body pictures (z = -2.75, p = .01, r = .27), with a small-to-medium effect size.

What effect did the picture cues have on performance?

Mean tactile and visual performance (IE) in each of the picture conditions is displayed in Figure 7.2 below. Visual performance was poorer than tactile performance in each of the picture conditions.

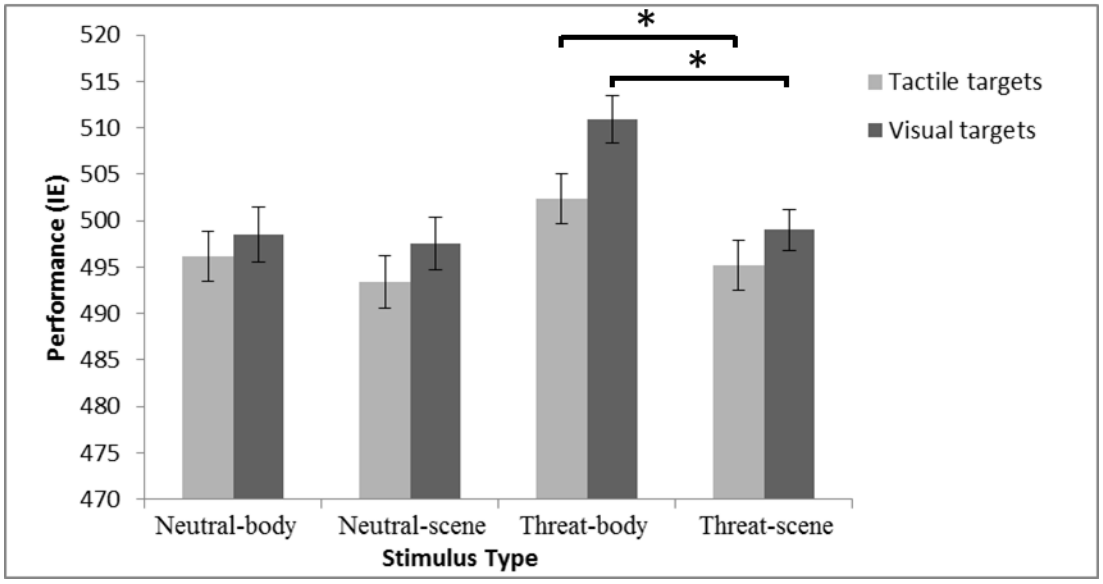

*Figure 7.2 Adjusted mean (SE) tactile and visual performance (IE) for each stimulus type (note * indicates significant interaction; p < .05).*

The performance data were analysed with a 2 (picture-valence: neutral vs. threatening) x 2 (picture-type: body vs. scene) x 2 (target-type: tactile vs. visual) repeated measures ANOVA. There was a highly significant main effect of picture valence (F, (1, 105) = 7.17, p =.01, η^2 = .06), with poorer performance following threatening pictures than neutral pictures (neutral mean = 496.39; threatening mean = 501.87). There was also a significant effect of picture type (F, (1, 105) = 5.27, p =.024, η^2 =.05), with poorer performance following body-relevant pictures than body-irrelevant pictures (body mean = 501.97; scene mean = 496.30). There was a non-significant effect of target-type (F, (1, 105) = 2.26, p =.14, η^2 =.021). There was a near significant picture-valence × picture-type interaction (F, (1, 105) = 3.67, p =.06, η^2 =.03). There were no other significant interactions (picture-valence × target-type: F, (1, 105) = .29, p >.05; picture-type × target-type: F, (1, 105) = .195, p = .66; picture-valence × picture-type × target-type: F, (1, 105) = .55, p >.05). The near significant interaction between picture-valence and picture-type was investigated with follow-up ANOVAs, which were conducted separately for neutral and threatening pictures.

Neutral pictures

There were no significant main effects (picture-type: F, (1, 105) = .43, p > .05; target type: F, (1, 105) = .28, p > .05) or interactions (picture-type × target type: F, (1, 105) = .89, p > .05) for performance following neutral pictures.

Threatening pictures

There was a highly significant main effect of picture-type (F, (1, 105) = 10.12, p = .002, η^2 = .09), with performance following body-relevant pictures being poorer than body-irrelevant pictures (scene mean = 497.11; body mean = 506.63). There was a non-significant effect of target-type (F, (1, 105), 2.34, $p > .05$), and a non-significant picture-type × target-type interaction (F, (1, 105) = 0.46, $p > .05$). This indicates that poorer performance following threatening body-relevant stimuli compared with threatening body-irrelevant stimuli was the source of the significant picture-valence × picture-type interaction.

Does the revised thresholding procedure for the SSDT yield thresholds within the expected range for at least 80% of participants?

The median block 1, light-absent hit rate (64.29 % (IQR, 43.00)) was higher than the upper limit of the 40-60% range expected for single interval trials. A further analysis of the range of block 1 light-absent hit rates revealed that 2 participants had hit rates of less than 10%, and 16 had hit rates greater than 90%. This suggests the threshold procedure was less accurate for 16.8% of the sample but that 83.2% of the samples thresholds were within the expected range. As the median block 1 light-absent hit rate was outside the upper limit of the 40-60% range (which is considered to represent tactile threshold), participants with hit rates greater than 90% and less than 10% were excluded from the rest of the analysis.

When those with tactile thresholds outside the upper and lower limits were excluded, the mean light-absent hit rate was within the 40-60% range considered to represent tactile threshold (see Table 7.2 below).

Table 7.2 *Median (IQR), hit rate, false-alarm rate, d (sensitivity) and c (response bias) in light-absent and light-present conditions of the SSDT. Tests of difference (effect size) for effect of block and light on: hits, false alarms, d', and c (n=89).*

	% hits	**% false alarms**	***d'***	***c***
Block 1				
Light-absent	50.00 (19.00)	11.90 (19.00)	1.39 (0.83)[a]	.62 (0.46)[a]
Light-present	64.29 (33.00)	11.90 (14.00)	1.64 (0.86)[a]	.39 (0.51)[a]
Block 2				
Light-absent	59.52 (48.00)	7.14 (10.00)	1.55 (1.06)[a]	.66 (0.58)[a]
Light-present	69.05 (48.00)	11.90 (10.00)	1.68 (0.97)[a]	.35 (0.59)[a]
Effect of block				
Light-absent	-0.24	-2.86** (-.30)	-1.01 [b]	-1.50 [b]
Light-present	-0.45	-0.35	-0.49 [b]	-0.36 [b]
Effect of light				
Block 1	-5.41*** (.58)	-0.96	-3.94*** (.46)[b]	5.41*** (.50)[b]
Block 2	-5.90*** (.63)	-3.60*** (.38)	-3.09** (.32)[b]	7.22*** (.61)[b]

[a] means (S.D.) are given because data were normally distributed; *p < .05. ** p < .01. *** p < .001; Significant differences are Wilcoxon matched pairs because of non-normal distributions of the data and [b] indicates *t*-test because data was normally distributed.

Does the revised thresholding procedure yield thresholds that have adequate test-retest reliability?

The test-retest correlation for the subset of participants who completed the thresholding procedure twice was r_s = .81 (p < .001), and there was no significant difference between pre- and post- tactile thresholds (z = -1.19, p > .05). This indicated that tactile thresholds were reliably determined by the computerised forced choice procedure.

Is there a significant effect of block and light on participant performance?

The effect of block

For light-absent trials: hit rate, tactile sensitivity and response bias were not significantly different between block 1 and 2, however, false alarm rate was significantly lower in block 2. For light-present trials there were no significant differences between block 1 and 2 for any of the SSDT variables. As there were significant differences between

false alarms between block 1 and 2 in light-absent trials, the effect of the light was assessed for each block individually.

The effect of the visual stimulus

In block 1, participants' hit rate, tactile sensitivity (*d*') and tendency to say yes (*c*) were all significantly increased by the presence of the visual stimulus. False alarm rate, however, was not significantly increased by the presence of the visual stimulus.

In block 2, hit rate, false alarm rate, tactile sensitivity (*d*') and tendency to say yes (*c*) were all significantly increased by the presence of the light.

Manipulation check

Descriptive statistics for pre- and post- MBT and negative mood induction mood and symptom experience scores are presented in Table 7.3 below. Cronbach's α indicated that the mood scale and adapted symptom checklist (SCL) were reliable measures.

Table 7.3 Median (IQR), Cronbach's α pre- and post- MBT, and negative induction, mood and symptom (SCL) rating scores (n=107).

	Pre-		**Post-**		**Pre-**		**Post-**	
	MBT				**Negative mood induction**			
	Mood	**SCL**	**Mood**	**SCL**	**Mood**	**SCL**	**Mood**	**SCL**
Median (IQR)	3.20 (4.60)	13.00 (17.00)	6.00 (8.20)	10.00 (14.00)	2.10 (4.60)	6.00 (9.00)	9.20 (10.80)	8.00 (13.00)
Cronbach's α	.61	.82	.78	.85	.77	.83	.77	.87

SCL = Adapted Symptom Checklist.
A higher score indicates poorer mood and symptom experience

Both the MBT and negative mood induction had a significant effect on participants mood (χ^2 (3), 134.43, p = .00) and symptom experience (χ^2(3), 151.53, p = .00).Wilcoxon tests were used to follow-up these findings. Participants rated their mood as being significantly poorer post-MBT, (z = -6.98, p = .00, r = -.68), compared to pre-MBT. Symptom experience, however, significantly improved post-MBT (z = -4.40, p = .00, r = -.43). Poorer mood post-MBT was relatively short lived as pre-negative mood induction mood was significantly improved compared to post-MBT mood (z = -7.56, p = .00, r = -

.73). Symptom experience had also further improved (z = -8.36, *p* =.00, *r* = -.81). Indeed, pre- negative induction mood (*z* = -3.15, *p* =.002, *r* = -.31) and symptom experience (z = -8.29, *p* = .00, *r* = -.80) were significantly improved compared to pre- MBT mood and symptom experience. Taken together, these findings suggest that the rest break was sufficient. Participants rated their mood (*z* = -7.85, *p* = .00, *r* = -.76) and symptom experience *(z* = -5.82, *p* = .00, *r* = -.57) as significantly poorer post- induction compared to pre- induction. This suggests the negative mood induction was successful.

7.4.2. *Discussion of the preliminary analysis*

The aims of the preliminary analysis were to further investigate the processes measured by the tasks (SSDT & MBT), and to check that the negative mood induction provided an effective manipulation.

Reliability and validity of the MBT

Threat ratings of the pictures presented in the MBT confirmed that neutral pictures were rated as significantly less threatening. These differences yielded large sized effects and indicate that the manipulation was effective. There were also significant differences between the perceived level of threat presented by body-relevant and irrelevant pictures in threatening and neutral conditions. However, these differences yielded only small-to-medium sized effects.

In contrast with the findings of the original MBT study, the pilot study (Ch. 3), and the primary care study (Ch. 4), visual performance in the present study was poorer, but not significantly poorer, than tactile performance. This finding is likely due to the restricted age range (18.01-28.01 yrs) in this study.

The presentation of neutral body-relevant and irrelevant pictures did not have significantly different effects on disengagement for visual or tactile targets. This is in contrast to the findings of Chapter 4, where presenting neutral body-relevant material led to facilitation for the tactile modality, and a simultaneous cost for the visual modality. That finding indicated that presenting neutral body-relevant pictures primes the tactile modality; however, this has not been replicated in the present study. This may indicate that the 'body priming effect' is only present in individuals with increased levels of physical symptoms and health anxiety, such as those observed in the primary care sample. Further research is

necessary to investigate whether the body priming effect can be replicated in those reporting high levels of physical symptoms and health anxiety.

In line with previous findings, the effect of presenting threatening body-relevant pictures appears to be supramodal, with performance being significantly poorer in this condition for both visual and tactile targets. This suggests that disengagement is slower for this type of material. In line with the findings of the previous chapters, threatening body-irrelevant pictures were rated as significantly more threatening than threatening body-relevant pictures. The stronger disengagement effects found for threatening body-relevant material, therefore, do not appear to be driven by perceived level of threat; rather the effect appears to be related to the picture content itself.

Reliability and validity of the tactile thresholding procedure

An initial screen of light-absent hit rates revealed that the group median hit rate was outside the upper limit of the 40-60% range expected for single interval trials. The exclusion of participants (16.8%) with hit rates outside the upper and lower limits (> 90% and less than < 10%) brought the mean within the 40-60% range for single interval trials. Thus the probability of detecting the tactile stimulus was above chance, but remained difficult enough to induce uncertainty. The tactile threshold was reliably determined, as indicated by the high test-retest correlations and non-significant tests of difference. In line with the findings of Chapter 5, the majority of participants outside the upper and lower limits had hit rates greater than 90%. This suggests that the threshold procedure could be further improved (see Chapter 5 for a full discussion).

Reliability and validity of the SSDT

Consistent with previous SSDT studies, the presentation of the light increased hit rates, tactile sensitivity, and the tendency to say yes in both block 1 and 2 (e.g. Brown et al., 2010; Brown et al., 2012). These results provide further evidence of both the validity of the threshold procedure and the reliability of the paradigm. False alarm rate was not significantly increased by the presence of the light in block 1; in block 2, the presence of the light did lead to a significant increase in false alarm rate. SSDT research with non-clinical symptom reporters and healthy participants has found the effect of the light on false alarm rates to be inconsistent. Some studies have found that the presentation of the

light leads to significantly increased false alarm rates (Lloyd et al., 2008; McKenzie et al., 2011; Brown et al., 2012); others, however, have not (Brown et al., 2010; Katzer et al., 2011).

In line with the findings of the previous chapters, there was a significant effect of test half on false alarms, such that false alarm rates decreased in block 2. This time the effect was found in the light-absent condition. Hit rates, tactile sensitivity and response bias remained stable across test-halves. This pattern of results is the same as that observed in Chapter 3, where false alarms decreased in the light-absent condition on block 2 of the task. However, in contrast to Chapter 3 and 5, significant increases in tactile sensitivity were not observed. As tactile sensitivity and response bias (tendency to say yes) remained relatively stable across the blocks, the reduction in false alarms observed here seems to be specifically related to better judgment of when the stimulus was absent in the absence of the light. Because there was a significant decrease in light-absent false alarms on block 2 of the task, change in false alarm rate in light-absent and light-present trials were calculated and analysed as additional predictors in subsequent analyses, in line with the analysis conducted in Chapter 5.

The effect of the negative mood induction and MBT on mood and symptom experience

The results indicate that the negative mood induction significantly increased both negative mood and symptom experience. This suggests the mood induction provided an effective manipulation of both mood and symptom experience.

The results also suggest that the MBT had a significant effect upon mood, but not upon symptom experience. Indeed, post-MBT symptom experience had significantly improved compared to pre-MBT symptom experience. Furthermore, following the rest-break, participants' mood and symptom experience had significantly improved compared to pre-MBT mood and symptom experience. This suggests that the SSDT may have had a negative effect on pre-MBT mood and symptom ratings. The time taken to complete the SSDT varies depending on the length of time taken to reach tactile threshold. For some participants the length of time taken to complete the task may be particularly burdensome. The task also involves concentrating on the body for a prolonged period of time and some participants may also find this unpleasant. The MBT does not appear to increase symptom experience, although the MBT also involves attending to the body and also to the presentation of pictures with threatening content. The MBT, however, is a considerably

shorter task, with what may be considered a greater cognitive load. These findings suggest that long tasks with low cognitive load may serve as effective mood and symptom inductions in their own right. Indeed, a number of studies have found that symptom reports increase in boring environments (i.e. under low perceptual load; Pennebaker, 1982; Pennebaker & Lightner, 1980; Pennebaker & Brittingham; 1982). However, a pre- SSDT measurement was not taken and it is possible that mood and symptoms were stable over the course of the SSDT and only changed following the MBT and the rest break.

It is interesting that in Chapter 5 somatic distortion was correlated with health anxiety and symptom reporting in block 2, rather than block 1. It is possible that experience of the task induces negative mood and symptoms that increase the tendency to experience distortions, particularly for those who are already experiencing symptoms and health anxiety. Experimental evidence has shown that high trait NA and high symptom-reporting females make, when primed, more negative symptom attributions under conditions of low internal perceptual load. This finding has been interpreted as a tendency to rely on schema-driven interpretations of sensations, rather than bottom-up sensory information (Bogaerts et al., 2010). Further research taking pre- and post- SSDT mood and symptom measurements is needed to further explore this possibility.

7.4.3. *Primary analyses*

Do false alarms and tactile threshold predict post- mood induction symptom experience?

There were no significant relationships between false alarm variables, tactile threshold, and post- mood induction symptom experience (see Table 7.4 below).

Table 7.4 *Zero-order correlations between false alarms (FAs) in block 1 (B1) and 2 (B2) and change in false alarm rate in light-absent (LA) and light-present (LP) conditions, average tactile threshold and post- induction symptom experience.*

	FAs (*n=89*)						*tactile threshold (n=55)*
	B1		*B2*		*Change*		
	LA	LP	LA	LP	LA	LP	
Post- induction symptoms	.10	.07	.04	.06	-.06	-.04	-.12

*$p < .05$. ** $p < .001$.

In order to investigate whether false alarm variables and tactile threshold were predictive of post- induction symptom experience when controlling for covariates, a series of hierarchical regressions were carried out taking post- induction symptom experience as the target variable. False alarms in each block (1 & 2) and light condition (light-absent & light-present), false alarm change in both light conditions and tactile threshold were taken as predictors in step 2 and with covariates (age, gender, health anxiety, trait anxiety, depression, anxiety, pre- induction mood and symptoms) in step 1. As pre- and post-induction symptom experience was highly correlated with one another pre-induction symptom experience was log transformed before being entered into the regression equation as a covariate. This reduced the correlation between the two variables to a magnitude which met the assumptions of multiple regression analysis. In each of the analyses, the regression diagnostics indicated that the assumptions of multiple-regression had been met. Full details of each of the regressions can be found in Appendix E, Section E.4.

None of the predictors led to a significant improvement in the regression equations (Table 7.6). Trait anxiety (*B range = 0.75-0.80*, *SEB range* = 0.38-0.39*, β range = .19-.20*, $p < .05$) and pre-induction symptoms (*B = 0.03*, *SEB* = 0.00*, β range = .69- .72*, $p < .05$), were significant unique predictors in the final regression models. The direction of the coefficient was positive, which indicates that increased trait anxiety and pre-induction symptom experience were associated with increased post-induction symptom experience.

Table 7.5 Summary of hierarchical regressions predicting post- negative induction symptom experience from false alarm variables and controlling for covariates (n=89).

	Post- Induction Symptoms		
	B	*SEB*	*β*
Tactile threshold	-.00	.00	-.13
Block 1			
Light-absent			
FAs	0.01	0.24	.00
Light-present			
FAs	-0.17	0.25	-.05
Block 2			
Light-absent			
FAs	0.07	0.33	.02
Light-present			
FAs	-0.14	0.24	-.05
Change			
Light-absent	0.04	0.28	.01
Light-present	0.01	0.22	.00

*$p < .05$. ** $p < .001$

Do enhanced disengagement in the neutral-scene condition and delayed disengagement in the threat-body condition predict post- mood induction symptom experience?

There were no significant correlations between visual and tactile performance in the threat-body condition, neutral-scene conditions and post- induction symptom experience (Table 7.6).

Table 7.6 Zero-order correlations between MBT task performance in neutral-scene and threat-body conditions and post- negative induction symptoms (SCL).

	Visual targets		**Tactile targets**	
	Neutral- scene	Threat-body	Neutral-scene	Threat-body
Post- induction symptoms	-.08	-.05	-.07	-.09

*$p < .05$. ** $p < .001$

In order to investigate whether attentional disengagement is predictive of post-negative induction symptom experience when controlling for covariates, a series of hierarchical regressions were carried out taking post- mood induction symptom experience as the target variable. Visual and tactile performance in the threat-body condition were taken as predictors in step 2, with covariates (age, gender, health anxiety, trait anxiety, depression, anxiety, pre- mood induction mood, symptoms and neutral-scene performance) in step 1. In each of the analyses, regression diagnostics indicated that the assumptions of multiple-regression had been met (see Appendix E for full details of the regression analyses).

Neither visual ($B = 1.27$, $SEB = .70$, $\beta = .24$, $p < .05$) or tactile ($B = .06$, $SEB = .64$, $\beta = .01$, $p < .05$) performance in the threat-body condition led to a significant improvement in the regression equations. The addition of threat-body visual performance led to a near significant improvement in the regression equation ($\Delta R^2 = .01$, $p = .07$). The direction of the coefficient was positive which indicates that poorer visual performance following threatening body-relevant pictures was associated with increased post-induction symptom reporting. Furthermore, the predictive value of neutral-scene performance became significant ($B = -1.07$, $SEB = .74$, $\beta = -.20$, $p < .05$) when threat-body performance was included. The direction of the coefficient was negative which indicates that better visual performance following neutral-scene pictures was associated with increased post-induction symptom reporting. When neutral-scene performance was included as a predictor on its own the coefficient was positive and non-significant ($B = .11$, $SEB = .36$, $\beta = .02$, $p > .05$). This suggests a suppressor effect (see Chapter 4, Section 4.6.3 for a full discussion of statistical suppression).

Age (all $B = -0.04$, *all SEB* = 0.02, *all* $\beta = -.14$, $p < .05$), trait anxiety (*B range* $= 0.77\text{-}0.83$, *all SEB* = 0.33, β *range* $= .19\text{-}.20$, $p < .05$) and pre-induction symptoms (all $B = 0.03$, *all SEB* = 0.00, β *range* $= .72\text{-}.73$, $p < .05$) were significant unique predictors. The

direction of the coefficients was positive, which indicates that increased age, trait anxiety and pre- induction symptom experience were associated with increased post- induction symptom experience.

Do individual differences in mood in response to the negative mood induction predict the development of post-induction physical symptoms?

A hierarchical regression was carried out taking post-induction symptom experience as the target variable. Change in post-induction mood (post-induction mood total minus pre-induction mood total) was taken as the predictor in step 2, with covariates (age, gender, health anxiety, trait anxiety, depression, anxiety, and pre- induction symptoms) in step 1. As pre- and post-induction symptom experience were highly correlated with one another, pre-induction symptom experience was log transformed before being entered into the regression equation as a covariate. The regression diagnostics indicated that the assumptions of multiple-regression had been met (full details of the regression can be found in Appendix E, Section E.4).

The inclusion of change in mood led to a significant improvement in the regression equation (B = 0.02, SEB = 0.00, β = .35, p < .001). Pre-induction symptoms (B = 0.03, SEB = 0.00, β = .72, p < .001), was also a significant unique predictor in the final regression model. The direction of both coefficients was positive, which indicates that poorer mood in response to the mood induction and increased pre-induction symptom experience were associated with increased post-induction symptom experience.

7.4.4. *Secondary analysis*

Are there significant relationships between MBT performance, retrospective symptom reporting and health anxiety?

Table 7.7 below displays zero-order correlations between MBT performance, retrospective symptom reporting on the PHQ-15 and health anxiety. There were no significant correlations between MBT performance, symptom reporting and health anxiety.

Table 7.7 Zero-order correlations between MBT performance, symptom reporting and health anxiety (n =106).

	PHQ-15	HAI
Tactile targets		
Neutral-body	.01	.06
Neutral-scene	.05	.16
Threat-body	.02	.15
Threat-scene	.02	.12
Visual targets		
Neutral-body	-.00	.10
Neutral-scene	.03	.14
Threat-body	.04	.12
Threat-scene	.07	.19

*$p < .05$. ** $p < .001$.

Is there a significant relationship between MBT performance, retrospective symptom reporting and health anxiety when controlling covariates?

A series of hierarchical regressions were carried out taking total PHQ-15 score and total health anxiety score as the target variables. Visual and tactile performance in neutral-body, threat-scene and threat-body conditions were taken as predictors in step 2 with covariates (age, gender, STAI-T, GAD-7, PHQ-9, and neutral-scene performance) in step 1. In addition to these covariates, health anxiety was controlled for in the analyses focusing on symptom reporting and symptom reporting was controlled for when focusing on health anxiety. In each of the analyses, the regression diagnostics indicated that the assumptions of multiple-regression had been met. To aid clarity summary regression tables have been provided (see Table 7.8 below; full details of each of the regressions can be found in Appendix E, Section E.4).

Symptom reporting

None of the predictors led to a significant improvement in the regression equations.

Gender (*B range = 0.37-0.39*, all *SEB* = 0.13*, β range* = .20-.22, all *p's* < .05), and anxiety (all *B = 0.09, all SEB* = .02*, β = .47-.49,* all *p's* < .001), were unique predictors of symptom reporting in the final regression equations. The direction of the coefficients was positive, which indicates that being female and increased anxiety were independently associated with increased symptom reporting.

Health anxiety

None of the predictors led to a significant improvement in the regression equations. However, tactile performance in the neutral-scene condition became a significant predictor when neutral-body performance was entered in the regression equation (*B = 4.67*, *SEB* = 2.39, *β = .41*, *p* < .05). The direction of the coefficient was positive, which indicates that poorer performance in the neutral-scene condition was associated with increased health anxiety.

Table 7.8 Summary of hierarchical regressions predicting symptom reporting (PHQ-15) and health anxiety (HAI) from MBT performance controlling for covariates (n = 106). Full details of regressions and covariates can be found in Appendix E, Section E.4

	PHQ-15			HAI		
	B	*SEB*	*β*	*B*	*SEB*	*β*
Tactile targets						
Neutral-body	-0.71	1.57	-.08	-3.46	2.32	-.31
Threat-scene	-0.06	1.58	-.01	0.04	2.38	.00
Threat-body	-0.90	1.32	-.10	0.91	2.00	.08
Visual targets						
Neutral body	-2.66	1.50	-.25	-0.21	2.34	-.02
Threat-scene	0.31	1.77	.03	3.21	2.65	.27
Threat-body	0.22	1.46	.02	-0.48	2.22	-.04

*p < .05. ** p <.001

Are false alarms (somatic distortion) and tactile threshold associated with symptom reporting and health anxiety?

False alarm rates and average tactile threshold were not significantly associated with symptom reporting or health anxiety[7] (see table 7.9 below).

Table 7.9 Zero-order correlations between false alarm variables, average tactile threshold, symptom reporting and health anxiety (n=89).

	Block 1		**Block 2**		**Change**		
	Light-absent	Light-present	Light-absent	Light-present	Light-absent	Light-present	Ave. tactile threshold
PHQ-15	.01	.08	-.04	-.01	-.03	-.03	-.24
HAI	-.02	.09	-.01	.15	-.04	.03	-.25

Is there a significant relationship between tactile threshold, false alarms, symptom reporting and health anxiety when controlling for covariates?

In order to further explore the relationships between false alarms, tactile threshold, symptom reporting and health anxiety, hierarchical regressions were carried out separately taking symptom and reporting health anxiety as the target variables. Average tactile threshold and false alarm variables in both blocks (1 & 2) and light conditions (light-absent & light-present) were taken as predictors in step 2 with covariates (age, gender, STAI-T, GAD-7, PHQ-9) in step 1. In addition to these covariates, health anxiety was controlled for in the analyses focusing on symptom reporting and symptom reporting was controlled for when focusing on health anxiety. In each of the analyses, the regression diagnostics indicated that the assumptions of multiple-regression had been met. To aid clarity, summary regression tables have been provided (see Table 7.10); full details of each of the regressions can be found in Appendix E, Section E.4.

[7] There were also no other significant correlations between SSDT performance variables, symptom reporting and health anxiety.

Symptom reporting

None of the predictors led to a significant improvement in the regression equations.

Gender (*B range = 1.66-1.88, all SEB* range = 0.78-0.79*, β range* = 0.17-0.19, all *p's* < .05), and anxiety (*B range = 0.52-0.54, all SEB* = .02*, β = 0.10-0.12*, all *p's* < .001), were unique predictors of symptom reporting in the final regression equations. The direction of the coefficients was positive, which indicates that being female and increased anxiety were independently associated with increased symptom reporting.

Health anxiety

None of the predictors led to a significant improvement in the regression equations. However, there was a trend for block 2 light-present false alarms to be independently associated with health anxiety (R^2 = .03, *p* = .08). Age (*B range = 0.15-0.18, SEB* = 0.06-0.08*, β = 0.24-0.32*, all *p's* < .05), was a significant unique predictor of health anxiety in the final regression equations. The direction of the coefficient was positive, which indicates that being older was associated with increased health anxiety.

Table 7.10 Summary of hierarchical regressions predicting symptom reporting (PHQ-15) and health anxiety (HAI) from tactile threshold (n = 55) and false alarms variables controlling for covariates (n = 89). Full details of regressions and covariates can be found in Appendix E, Section E.4

	PHQ-15			*HAI*		
	B	*SEB*	*β*	*B*	*SEB*	*β*
Ave. tactile threshold	0.00	0.00	.09	0.00	0.00	-.22
FAs						
Block 1						
Light-absent	1.54	2.29	.05	0.77	0.71	.11
Light-present	-0.17	2.43	-.01	0.63	0.75	.09
Block 2						
Light-absent	4.84	3.19	.12	1.58	0.99	.16
Light-present	3.27	2.35	.11	1.30	0.72	.18
Change						
Light-absent	0.31	0.54	.05	-0.00	0.88	.00
Light-present	.60	.42	.11	0.57	0.69	.09

*p < .05. ** p < .001.

7.5. Discussion

7.5.1. *Evaluation of the primary study hypotheses*

Contrary to the primary hypotheses the tendency to experience distortions in somatic awareness, tactile threshold and attentional disengagement in neutral body-irrelevant or threatening body-relevant conditions were not significant predictors of post-induction symptom experience. This suggests that individual differences in the tendency to experience distortions in somatic awareness, tactile threshold and attentional disengagement do not predict the development of symptoms following a negative event. This evidence contradicts the model of Brown, which suggests that those with a tendency to experience distortions in somatic awareness and increased levels of symptom-focused attention may be more likely to develop physical symptoms following a negative event. Nor does it support the model of Rief and Barsky, which suggests that those with deficits in a hypothesised somatosensory filter are more likely to develop physical symptoms following a negative event.

The same pattern of effects found in Chapter 4 was observed for visual performance in the present chapter. That is, when relevant covariates were controlled for, better performance following neutral body-irrelevant pictures and poorer performance following threatening body-relevant pictures were associated with post-induction symptom experience. Furthermore, consistent with the findings of Chapter 4, simultaneously entering performance following neutral body-irrelevant pictures and performance following threatening body-relevant pictures, improved the predictive power of both variables, as well as the predictive power of the regression equation, indicating a 'suppressor' effect (see Chapter 4 for a full discussion of suppressor effects).

Pre-induction symptoms and mood were highly correlated with post- induction symptoms and it is likely that once this, along with other covariates, was controlled for in the regression analysis there was very little variance left in post-induction symptom reporting for attentional disengagement or somatic distortion to account for. The replication of the effect found in Chapter 4 (which concerned health care utilisation) in relation to post-induction symptom experience is encouraging. It suggests that attentional factors such as hypervigilance for the body (improved performance following neutral body-irrelevant material) and poorer disengagement from symptom-relevant material (poorer performance following threatening body-relevant material) may be risk factors for

the development of physical symptoms following a negative event. These findings therefore provide some tentative support for the role of attention in the development of physical symptoms. In particular, this finding provides some support for the model of Brown, which suggests that both hypervigilance for the body and difficulties disengaging symptom focused attention, may be risk factors for the development of MUS.

In line with the primary hypothesis, poorer mood in response to the negative mood induction predicted post-induction symptom development independently of age, gender, psychopathology (health anxiety, trait anxiety, state anxiety & depression) and pre-induction symptom experience. This finding provides evidence regarding the causative role acute negative emotional states play in the development of physical symptoms. Negative emotional states are thought to increase the likelihood of negative interpretations of ambiguous sensations, as well as increase attention to the body or specific somatic experiences (Stegen, Van Diest, Van de Woestijne, & Van den Bergh, 2011; Wells & Matthews 1994; Gendolla, Anele, Andrei, Spurk & Richter, 2005). However, processes such as these were not measured post-induction, meaning that the processes that mediate the relationship between negative affect and symptom development remain unclear.

Cognitive processes, such as, the tendency to experience distortions in somatic awareness, more sensitive tactile thresholds, hypervigilance for the body and difficulties disengaging symptom-focused attention may only be activated under conditions of stress (i.e. a negative mood induction). This may be especially true of non-clinical symptom reporters. Perhaps only high symptom reporters, display high levels of somatic distortion, more sensitive tactile thresholds, hypervigilance and delayed disengagement irrespective of mood state (See Chapter 8 for a discussion of the continuum hypothesis in relation to attention and somatic awareness).

7.5.2. *Evaluation of the secondary study hypotheses*

Contrary to the secondary study hypotheses, attentional disengagement, somatic distortion, and tactile threshold were not associated with retrospective symptom reporting on the PHQ-15 or health anxiety in the present sample. In Chapter 3, MBT performance was found to be independently associated with both health anxiety and symptom reporting. Enhanced disengagement in the neutral body-irrelevant condition was found to be independently associated with health anxiety, whilst delayed disengagement in the same condition was found to be independently associated with symptom reporting. In Chapter 4,

no such associations were found, however, enhanced performance in the neutral body-irrelevant and delayed disengagement in the threatening body-relevant condition, were found to be independent predictors of health care utilisation at 6 month follow-up. The present findings are therefore in line with those of Chapter 4.

In contrast to the findings of Chapter 5, in the present study none of the false alarm (i.e. somatic distortion) variables were associated with symptom reporting or health anxiety. This finding was unexpected as there is an increasing body of evidence suggesting that the tendency to experience distortions in somatic awareness is associated with symptom reporting and health anxiety in clinical and non-clinical symptom reporters (Brown, et al., 2010; Katzer et al., 2011; Brown et al., 2012; Katzer et al., 2013). Although there were a number of participants reporting clinically relevant levels of symptom reporting and health anxiety, the range of symptom reporting was relatively restricted. There are likely to be multiple sources of variation in the lower range of symptom reporting, such as acute illness, psychopathology and medical conditions, which may reduce the strength of the relationship between somatic distortions, symptom reporting and health anxiety. Symptom reporting in the high range is less likely to be associated with multiple sources of variation and to be more strongly related to cognitive processes such as somatic distortion and disengagement effects, which would likely increase the strength of correlational relationships.

In line with the findings of Chapter 3 and 5, tactile threshold was not associated with symptom reporting or health anxiety. This suggests that symptom reporting and health anxiety are not associated with an enhanced, or indeed, decreased ability to detect subtle somatosensory signals. This finding is consistent with the previous findings of Katzer et al's. (2011). It has been suggested that MUS may be caused by a filtering deficit (Rief & Barsky, 2005). However, if such a deficit in the filter exists then it would be expected that those who experience greater numbers of symptoms would have lower (more sensitive) tactile thresholds. As no association was found in the present study, the idea that symptom reporting is due to a deficit in the filtering system is not supported by the present findings. However, the lack of a significant association in the present study may also be related to the restricted range of symptom reporting. Indeed, it is noteworthy that tactile thresholds were found to be more sensitive in participants diagnosed with SFD compared to healthy controls (Katzer et al., 2012)

7.5.3. *Strengths, limitations and future directions*

The main strengths of this study are its use of objective measures of somatic awareness and attention, the use of questionnaires measuring current symptom experience, the experimental manipulation of mood and symptom experience using a negative mood induction, and its application to a large sample of participants.

The main limitation to this study was that attention and somatic awareness were not measured post- induction. It remains unknown whether negative mood states increase the tendency to experience somatic distortions, hypervigilance for the body and delayed disengagement from threatening body-relevant stimuli in non-clinical symptom reporters.

Future research could investigate whether performance on the SSDT and MBT is affected by negative mood states. Furthermore, the results of Chapter 5 suggest that the tendency to experience somatic distortions is an independent predictor of health anxiety. The negative mood induction employed in the present study contained distressing scenes related to health. Thus future research might investigate whether somatic distortion predicts the development of state health anxiety following the present mood induction.

Chapter 8. General discussion

8.1. Review of findings

The general aim of this thesis was to investigate whether individual differences in attention and somatic awareness were associated with symptom reporting, health anxiety and health care utilisation. Two experimental paradigms were employed throughout this research: the MBT to measure attention and the SSDT to measure somatic awareness. The results of the studies presented here have provided some, albeit qualified, support for our initial hypotheses. The evidence pertaining to our initial hypotheses regarding attention (Section 8.1.1), somatic awareness (Section 8.1.2), the relationship between attention and somatic awareness (Section 8.1.3), and negative affect (Section 8.1.4) are summarised and discussed in the following sections.

8.1.1. *Attention*

Table 8.1 Summary of MBT findings

Study	**Population**	**Findings**
Pilot study	Students	Better tactile performance was found in all picture conditions. Poorer performance for both tactile and visual targets was associated with symptom reporting. Improved performance for tactile and visual targets was associated with health anxiety. The association between tactile bias and symptom reporting appeared to be driven by poorer performance for visual targets relative to tactile targets rather than by a bias for the tactile modality. When controlling for covariates, poorer performance in the neutral body-irrelevant condition was independently associated with increased symptom reporting and improved performance in the same condition was independently associated with increased health anxiety.

Primary care study	Primary care patients	Better tactile performance was found in all picture conditions. Presenting neutral body-relevant material resulted in worse performance for visual targets and better performance for tactile targets (i.e. a body priming effect was found) at T1, but not at T2. At T1, poorer performance was significantly associated with age, the presence of a medical condition, symptom reporting and health care utilisation. At T2, poorer performance was associated with age, medical conditions and health care utilisation. When relevant covariates were controlled for, delayed disengagement from threatening body-relevant material and enhanced disengagement from neutral body-irrelevant material were independent cross-sectional predictors of health care utilisation, but not symptom reporting or health anxiety. When controlling for T1 outcome variables and covariates disengagement effects did not predict T2 symptom reporting, health anxiety or health care utilisation. Nor did T1 symptom reporting, health anxiety or health care utilisation predict T2 disengagement effects when controlling for T1 disengagement effects and covariates.
Mood and bodily symptoms study	Students	Tactile performance was better in all picture conditions but not significantly so. No body priming effect was found for neutral body-relevant material. There were also non-significant relationships between attentional disengagement, post- induction symptom experience, health anxiety and symptom reporting. However, the same pattern of effects found in the primary care study between attentional disengagement and health care utilisation were found between attentional disengagement and post-induction symptom experience.

Models of symptom perception, MUS, and health anxiety generally propose that attention to the body is a causative factor in the development of physical symptoms (e.g., Pennebaker, 1982; Barsky & Wyshak, 1990; Warwick & Salkovkis, 1990; Cioffi, 1991; Brown, 2004; Rief & Barsky, 2005; Edwards et al., 2012). However, the specific processes involved in attention to the body have often not been specified in a way that allows clearly testable hypotheses to be derived (Miles, 2009). Hypervigilance for somatic sensations, a body-focused bias, avoidance of the body, and problems disengaging from the body, somatic sensations, or symptom representations, have all been hypothesised to operate. Furthermore, it has been suggested that attentional differences may only operate under conditions of threat, or more specifically body-relevant threat. Thus, the general hypothesis we investigated was that individual differences in attention to the body contribute to physical symptom reporting and health anxiety.

There is a paucity of research employing behavioural paradigms to assess the nature of attention to the body and its relationship with health anxiety and symptom reporting. Of those behavioural paradigms, few have assessed stimuli presented in the tactile modality, or the effect of body-relevant threat. Employing tactile stimuli would seem the most direct way of measuring the various hypothesised forms of attention to the body. A behavioural task which employed both visual and tactile stimuli and threatening body-relevant stimuli, the MBT, was identified from the literature. Previous research employing the MBT in a student sample found that high symptom reporting was associated with a significant tactile bias, immediately after the presentation of body-relevant threat, which disappeared after a slightly longer SOA. These results had been interpreted as suggesting that high symptom reporting was associated with a relatively automatic body-focused bias under conditions of body-relevant threat (Brown, Poliakoff & Kirkman, 2007).

The MBT was employed as a measure of attention throughout this thesis. Methodological changes were made to both the design and analysis of the MBT (see Chapter 3). In Chapter 3, the revised task was first piloted to assess its validity and reliability as a measure of attention, and in Chapters 4 and 7 the processes measured by the MBT were further investigated. Furthermore, in each study the relationship between MBT performance and self-report measures (i.e., physical symptom reporting, health anxiety, health care utilisation) was investigated. The findings from each of the studies are discussed in the following sections.

8.1.1.1. The MBT

A comprehensive and thorough analysis of MBT performance and its relationship with symptom reporting and health anxiety, further clarified the nature of the task. In the original MBT study, the degree to which participant's displayed a body-focused bias had been inferred by subtracting tactile performance from visual performance. In the present study, performance for visual targets was significantly poorer than performance for tactile targets, and this resulted in a positive tactile bias for all picture conditions. These findings were consistent with prior expectations regarding performance for visual and tactile targets and with the results of the original MBT study. However, in the pilot study (and primary care study), poorer performance for both visual and tactile targets was also associated with symptom reporting. This suggested that difficulties disengaging from the pictures were

associated with symptom reporting. Furthermore, it seemed that greater difficulties disengaging in the visual modality compared to the tactile modality were associated with symptom reporting. Thus, the significant tactile bias appeared to be driven by greater difficulties disengaging in the visual modality relative to the tactile modality, rather than a preference for the tactile modality. The task was therefore found to be both a valid and reliable measure of attentional disengagement from different types of visual cue. Tactile bias, however, did not appear to provide a measure of body-focused attention, as it had previously been interpreted in the original MBT study (Brown et al., 2007).

In both the pilot study and primary care study there was a wide age range of participants and visual performance was significantly poorer than tactile performance irrespective of picture condition. In the final study, however, the age range was more restricted and visual performance was poorer, but not significantly so. This suggests that age has an important effect on performance. Age related effects on performance have rarely been considered in research investigating attention and its relationship with health anxiety or symptom reporting. An important strength of the analysis employed in this research was the use of performance in the neutral body-irrelevant condition as a control for general performance. A control was used in order to partial out variance associated with factors unrelated to the effect of the picture stimuli (e.g. age, gender, medical conditions and psychopathology). Future research could employ a control condition involving geometric shapes of a similar complexity to the picture conditions in order to present a more neutral condition to control for general performance.

In Chapter 4, we did find some evidence of a body-focused bias. It was found that presenting neutral body-relevant material led to a simultaneous benefit for the tactile modality and a cost for the visual modality. This finding suggests that presenting neutral body-relevant pictures primes the tactile modality. The presentation of neutral body-relevant pictures did not have significantly different effects on disengagement for visual or tactile targets in Chapters 3 or 7. The lack of a body priming effect in these studies may indicate that the body priming effect found in Chapter 4 was related to the increased levels of physical symptoms and health anxiety reported in the primary care sample; alternatively this could be a spurious finding. Further research is necessary to investigate whether the body priming effect can be replicated in those reporting high levels of physical symptoms and health anxiety.

Furthermore, many of the pictures in the neutral body-relevant condition contained pictures of hands. It is likely that presenting such material facilitates detection of

subsequent tactile targets presented to the hands (Igarashi et al. 2008; Tipper et al., 1998). Future research should also investigate whether this potential priming effect is somatotopic (see Chapter 4, Section 4.6.3 for a full discussion). It might be expected that viewing pictures closely somatotopically related to the target location might produce a greater priming effect than those less closely related (e.g. pictures of the hand and face, rather than of the foot; Serino et al., 2009).

In all of the studies, delayed disengagement was greatest from threatening body-relevant stimuli and this effect appeared to be supramodal. In order to clarify whether this effect is indeed supramodal the MBT could be extended to incorporate auditory stimuli. Employing auditory stimuli would eliminate potential confounds in presenting targets in the same modality as the threatening picture cues. Thus, employing auditory stimuli may provide a clearer way of assessing individual differences in body-focused attention (tactile bias) and the effect of presenting threatening and neutral body-relevant and irrelevant stimuli on body-focused attention. The results of a recent temporal order judgement study employing tactile and auditory stimuli found that presenting threatening body-relevant, but not threatening body-irrelevant pictures led to priority processing of tactile over auditory stimuli, when those stimuli were spatially separated (Jia, Shi, Zang & Müller, 2013). It would be interesting to extend this task to include neutral body-relevant and irrelevant stimuli to determine whether this body priming effect pertains to the combination of body-relevant and threatening stimuli or body-relevant stimuli alone. Furthermore, this task could be used to investigate whether individual differences in tactile bias are associated with symptom reporting and health anxiety.

8.1.1.2. Attention in health anxiety, symptom reporting and health care utilisation.

The results of the pilot study suggest that non-clinical symptom reporting may be associated with delayed disengagement from neutral body-irrelevant material, whereas non-clinical health anxiety may be associated with faster disengagement from neutral body-irrelevant material. Both effects, however, were found in the visual, but not the tactile modality. These relationships were independent of one another as well as gender, age, trait anxiety, state anxiety and depression. This finding is interesting as it suggests that symptom reporting and health anxiety may be associated with opposite attentional processes.

In Chapter 4, it was found that health care utilisation, but not symptom reporting or health anxiety, was associated cross-sectionally with enhanced disengagement from neutral body-irrelevant pictures and delayed disengagement from threatening body-relevant pictures, irrespective of target modality. These relationships were independent of age, gender, medical conditions, symptom reporting, health anxiety, trait anxiety, state anxiety and depression. These results were further supported by the SEM analysis conducted in Chapter 6.

However, the longitudinal analysis revealed that when controlling for covariates, none of the MBT performance variables predicted T2 symptom reporting, health anxiety or health care utilisation. Nor did T1 health care utilisation predict T2 MBT performance when controlling for T1 MBT performance and T1 covariates. These results suggest that there may not be a causal relationship between attentional disengagement and health care utilisation, in either direction.

Interestingly, in Chapter 7, although the findings were non-significant, the same pattern of effects found in Chapter 4 was observed for visual performance in Chapter 7. That is, when relevant covariates were controlled for, improved performance following neutral body-irrelevant pictures and poorer performance following threatening body-relevant pictures was associated with post- induction symptom experience. Furthermore, consistent with the findings of Chapter 4, simultaneously entering performance following neutral body-irrelevant pictures and performance following threatening body-relevant pictures, improved the predictive power of both variables, as well as the predictive power of the regression equation indicating a 'suppressor' effect (see Chapter 4 for a full discussion of suppressor effects).

Attending to visual targets involved attending to the same spatial location as the body (hands, i.e., peripersonal space; for a review see Holmes & Spence, 2004). The detection of both types of target could therefore be considered to provide a measure of attention to the body. Thus, faster responses to both visual and tactile targets in the neutral body-irrelevant condition could be interpreted as a tendency to focus on, or hypervigilance for, the body under neutral conditions. Whilst under conditions of body-relevant threat, delayed disengagement effects were observed in both modalities, which suggests that body-relevant threat captures attention more strongly. It would be interesting to investigate whether hypervigilance for visual targets presented both outside and inside peripersonal space is associated with symptom reporting, health anxiety and health care utilisation.

Both hypervigilance and avoidance have been proposed to operate in anxiety states (e.g. Mogg et al., 2004) and have also been observed for high symptom reporters in the tactile modality following a trauma film (Brown et al., 2010). Whilst it is agreed that anxiety states are characterised by attentional biases towards threat, there is not yet a clear consensus on whether such attentional biases consist of hypervigilance for threat, delayed disengagement from threat or both (Cisler, Bacon & Williams, 2009; Cisler & Koster, 2010; Fox Russo, & Dutton, 2002). In the present research, delayed disengagement from body-relevant threat rather than avoidance was observed. However, delayed disengagement from the threatening body-relevant pictures also meant that performance for targets presented near or on the hands (attention to the body) was poorer. Thus delayed disengagement could be interpreted as avoidance of the body in response to threat. These results do not suggest that high health care utilisers are hypervigilant for threat and then orient away from body-relevant threat as is hypothesised to operate in anxiety states. Rather, they appear to be hypervigilant for the body under neutral conditions, and find it difficult to disengage from body-relevant threat, or are avoidant of the body in response to body-relevant threat. Similarly, a recent pictorial dot-probe study employing visual stimuli found that health anxiety was associated with hypervigilance for body-relevant threat and delayed disengagement from body-relevant threat, rather than avoidance of body-relevant threat (Witthöft & Jasper, 2011). Chronic pain has also been associated with hypervigilance for aversive stimuli (Notebaert et al., 2011).

To investigate whether symptom reporting, health anxiety and health care utilisation are associated with delayed disengagement from, or avoidance of body relevant-threat, a paradigm employing aversive and neutral tactile cue stimuli and non-aversive targets could be employed. Aversive and non-aversive tactile cue stimuli could be presented to the hands and performance for subsequent non-aversive cued and un-cued tactile, auditory and visual targets could be measured. The SOA between cue and target would be varied so that the time course of attention could be estimated (e.g., is avoidance or delayed disengagement exogenous or endogenous). The extent to which performance is poorer for targets at the cued relative to the un-cued location would suggest avoidance following aversive stimuli. The extent to which performance was improved for cued relative to un-cued targets would suggest delayed disengagement By using targets in all three modalities we could investigate whether avoidance and disengagement effects are supramodal, or whether effects are related to the modality in which the threat is presented.

The finding that symptom reporting and health anxiety were not associated with disengagement effects in Chapters 4 or 7 was unexpected. These results do not directly support theories which suggest that hypervigilance for the body and/or delayed disengagement from symptom relevant stimuli are causative factors in the development of physical symptoms or health anxiety (e.g. Brown, 2004; Barsky & Wyshak, 1990; Rief & Barsky, 2005).

However, health care utilisation is also considered an important indicator of health (Ritter et al., 2001). Health care utilisation (or, more specifically, reassurance seeking) is also considered an important maintaining factor in cognitive behavioural models of both MUS and health anxiety (Deary et al., 2007; Warwick & Salkovkis, 1990).

The cross-sectional association between health care utilisation and disengagement effects provides some, albeit limited evidence, for the role of attention. However, the longitudinal results suggest that a third unaccounted for variable is probably responsible for both disengagement effects and increased health care utilisation. Treatments targeting attentional effects such as these may therefore indirectly improve perceived health via another unknown variable or variables. This could help to break the vicious circle considered by cognitive-behavioural models to maintain symptom reporting and health anxiety (e.g., Deary et al., 2007).

Treatments could involve exposure to threatening body-relevant stimuli and attention training to facilitate enhanced disengagement from such stimuli. This might be achieved through the use of computerised tasks utilising reinforcement schedules.

An important limitation to be considered is that the measure of health care utilisation employed in this study, although broad and inclusive (i.e. it included private as well as NHS health care utilisation), relied on self-report and may not provide an entirely accurate measure. Research comparing self-report measures and medical records suggests that patients tend to under-report doctor visits (Ritter et al., 2001; Jobe et al., 1990; Cleary & Jette, 1984; Glandon, Counte, & Trancredi, 1992; Roberts et al., 1996), and over-report A&E visits (e.g. Ritter et al., 2001). Underreporting tends to increase as health care utilisation increases (Ritter et al., 2001). Although medical records are considered a 'gold standard', they do not capture visits to other health care providers (e.g. pharmacists and private health care). Future research could combine medical records and self-report to further improve accuracy.

The theories of symptom perception, MUS and health anxiety discussed throughout this thesis all propose that attentional abnormalities are central to the development and

maintenance of physical symptoms, health anxiety which in turn increase health care utilisation. The results of this study do not support the general hypothesis that attentional biases are central do the development of physical symptoms or health anxiety, nor do they support the more specific predictions made by dissociative, biopsychosocial, cognitive-attentional and neurobiological models.

Biopsychosocial models propose a general body-focused attentional bias and specific biases for illness-related information (Pennebaker, 1982; Barsky, & Wyshak, 1990; Cioffi, 1991; Rief & Barsky, 2005) to be associated with symptom reporting and health anxiety. If this was the case, we would expect hypervigilance for the body across all conditions and/or delayed disengagement from body-relevant threat to be associated with symptom reporting or health anxiety. Later cognitive-attentional (Brown, 2004) and neurobiological models (Edwards et al., 2012) of MUS have implicated attentional biases specifically for symptom representations or abnormal illness beliefs, rather than attention to the body per se. Thus we would expect to see disengagement effects in the threatening body-relevant condition only to be associated with symptom reporting and health anxiety.

The results reported throughout this thesis suggest that biases in attentional disengagement do not play a significant role in the development of physical symptoms, health anxiety or health care utilisation. Consequently the results of this thesis do not support the general predictions made by biopsychosocial, cognitive-attentional or neurobiological models that attention to the body or symptom relevant material are causative factors in the development of MUS or health anxiety.

It is important to note, however, that the work presented here has investigated one particular attentional process: attentional disengagement. As the MBT incorporated one short SOA (250 ms), the disengagement effects observed here relate to relatively automatic processes. However, other attentional strategies have been hypothesised as being relevant to symptom reporting and health anxiety, such as body-focused attention and avoidance of the body, which have not been investigated here. It remains unknown whether other attentional strategies also operate, in conjunction with the processes measured here. Additional research is necessary to investigate the relationship between individual differences in other hypothesised attentional processes (e.g., body-focused bias; avoidance of the body), symptom reporting, health anxiety and health care utilisation.

8.1.2. *Somatic awareness*

Table 8.2 SSDT results

Study	Population	Findings
Pilot study	Students	The computerised threshold procedure effectively determined threshold for 81.5% of participants. There was a significant reduction on block 2 for false alarms in light-absent trials. There were no significant relationships between false alarms or tactile threshold and health anxiety or symptom reporting. There was a negative association between symptom reporting and false alarms in both light-absent and light-present trials and, although non-significant, this yielded a medium sized effect.
Primary care study	Primary care patients	The computerised threshold procedure effectively determined threshold for 76.1% of participants at T1, and 85.7% of participants at T2. There was a significant reduction on block 2 for false alarm rate in light-present trials at T1, and a significant reduction for false alarm rate for light-absent trials at T2. The sustained tendency to experience false alarms in light-absent trials was an independent cross-sectional predictor of symptom reporting at T1, but not at T2 and the sustained tendency to experience light-present false alarms was an independent cross-sectional (both T1 & T2) predictor of health anxiety. When controlling for T1 outcome variables and covariates false alarms did not predict T2 symptom reporting, health anxiety or health care utilisation. However, T1 symptom reporting and health anxiety, but not health care utilisation, did predict T2 false alarms when controlling for T1 false alarms and covariates. Tactile threshold was not significantly associated with symptom reporting, health anxiety or health care utilisation.
Mood and bodily symptoms study	Students	The computerised threshold procedure adequately determined threshold for 83.2% of participants. There was a significant reduction on block 2 for false alarm rate, in light-absent trials. There were no significant relationships between false alarms or tactile threshold and post- induction symptom experience, health anxiety or symptom reporting. There was a significant relationship between tactile sensitivity and current symptom experience, however, when variance in age, gender, health anxiety, trait anxiety, state anxiety and depression were controlled for this relationship became non-significant. There were non-significant relationships between tactile threshold current/retrospective symptom reporting and health anxiety.

Models of symptom perception, health anxiety and MUS generally propose that altered somatic awareness is a causative factor in the development of physical symptoms. There are two main ways in which somatic awareness has been hypothesised to be altered. Biopsychosocial models suggest that the threshold or filtering system that determines which somatosensory information enters somatic awareness is altered via both selection and selective attention (Pennebaker, 1982; Barsky & Wyshak, 1990; Rief & Barsky, 2005). Such alterations are thought to increase the volume of somatosensory information that enters somatic awareness. This, coupled with the selective search for illness-relevant information, is thought to increase the perception of symptoms, thus providing evidence of illness. Therefore, these models would predict that high symptom reporters and highly health anxious individuals have a lower threshold for somatosensory signals (i.e. greater levels of sensitivity in somatic awareness), as well as a tendency to experience distortions in somatic awareness.

In contrast, cognitive-attentional and neurobiological models suggest that there may be a tendency to place greater weight on top-down factors relative to bottom-up factors in the creation of somatic awareness, which varies between individuals (Brown, 2004; Edwards et al., 2012). In the model of Brown (2004), the activation of rogue symptom representations stored in the cognitive system may explain the experience of MUS. If representations are activated by bottom-up information that is consistent with the representation, then the contents of somatic awareness reflect an objective reality. However, if rogue symptom representations are top-down activated, (i.e. bottom-up information is a poor fit with the selected representation) then experiencing such a representation reflects a distortion in somatic awareness. Brown's model would therefore predict a greater tendency to experience distortions in somatic awareness (i.e., more false alarms on the SSDT) in high symptom reporters, without alterations to the threshold at which somatosensory signals are perceived (i.e., no association between tactile threshold and symptom reporting).

The SSDT was developed in order to investigate the tendency to experience distortions in somatic awareness under controlled conditions. According to the Brown model, the experience of distortions on the SSDT is analogous to the experience of MUS. There is accumulating evidence to suggest that symptom reporting is linearly associated with the tendency to experience somatic distortions (Brown et al., 2010; Brown et al., 2012, Katzer et al., 2011), and more recently somatic distortion has also been associated

with health anxiety (Katzer et al., 2013). Methodological changes were made to the thresholding procedure employed in the SSDT to improve its effectiveness, so that tactile threshold could also be used as a measure of somatic awareness. We therefore hypothesised that more sensitive tactile thresholds and a greater tendency to experience somatic distortions would be associated with increased symptom reporting and health anxiety. In Chapter 3, the revised task was piloted in a student sample to assess its validity and reliability. In Chapters 5, 6 and 7 the validity and reliability of the SSDT was further investigated and the relationship between tactile threshold, the tendency to experience distortions, attention, health anxiety, symptom reporting and health care utilisation was assessed.

8.1.2.1. Tactile threshold

Katzer, et al., (2011) have criticised the single interval (yes/no) trial task employed in the thresholding procedure of previous SSDT studies. The authors suggest that in single interval trials the participant's response bias affects responses, thus reducing the accuracy of the thresholding procedure. In order to reduce the effects of response bias, the authors employed a more objective two-interval trial 'forced choice' task (Green & Swets, 1966). This procedure was found to be both valid and reliable for determining tactile threshold (Katzer et al., 2011). In the present study, the forced choice procedure implemented by Katzer et al., was computerised (i.e., using PEST; see Chapter 3, Section 3.1.2). This is an important development as it eliminates variability in technique, and human error, as sources of variation in the determination of tactile threshold. This allows more reliable comparisons to be made between groups. Furthermore, the tactile threshold itself could be empirically quantified and used as a measure of somatic awareness.

Although the results of Chapter 3, 5 and 7 indicate that the computerised forced choice procedure is both valid and reliable, there were some limitations. In Chapter 5, threshold was adequately determined in less than 80% of cases, although average light-absent hit rate was within the expected range (40-60%: tactile threshold). In Chapter 7, the threshold was adequately determined in more than 80% of cases, however, the average light-absent hit rate was greater than the upper limit of the expected range. In both cases, the majority of cases outside the upper and lower limits, had light-absent hit rates greater than the upper limit of the expected range. This suggests the procedure may need some adjustment. A small number of dummy light-absent trials could be presented before

starting the task to check hit rate and adjust accordingly, but adjustment would need to be made using experimenter judgement. This may reintroduce variation in technique and the possibility for human error, which would reduce the reliability of the procedure, making comparisons between groups more difficult. Alternatively, the probability threshold value, used in the Wald sequential probability ratio test, employed to define when to change the vibration strength, could be reduced.

Tactile threshold was not significantly associated with symptom reporting, health anxiety or health care utilisation in any of the studies reported here. This evidence suggests that neither symptom reporting, nor health anxiety, are associated with an enhanced ability to detect subtle somatosensory signals. The present findings are in contrast to a recent study by Katzer et al., (2012) who found that SFD patients had lower tactile thresholds than healthy controls. However, it is consistent with their earlier finding that non-clinical symptom reporting was not associated with tactile threshold (Katzer et al., 2011). The results of the present study do not support the model of Rief and Barsky (2005), which hypothesises that decreases in a somatosensory filtering mechanism increases the perception of physical symptoms. Nor do they support a somatosensory amplification model of health anxiety and symptom reporting (Barsky & Wyshak, 1990). According to both accounts, high symptom reporters and those high in health anxiety should be able to detect subtle sensations at reduced levels.

Previous research has found that attending to interoceptive (internal) sensations, using a heartbeat perception task prior to completing the SSDT, led to a significant increase in response bias on the task. This was due to non-significant increases in hit rate and false alarm rate (Mirams et al., 2011). In contrast, attending to exteroceptive (external) sensations, by using a grating orientation task prior to the SSDT, led to a significant decrease in response bias on the task. This was due to non-significant decreases in hit and false alarm rates (Mirams et al., 2011). Furthermore, it was found that completing a body-scan meditation (involving non-judgemental interoceptive attention) prior to the SSDT, decreased false alarms and increased sensitivity (Mirams et al., 2013). This evidence suggests that different types of attention have different effects on the ability to determine the presence or absence of subtle somatosensory signals. It would be interesting to investigate whether manipulations such as these also have a significant effect on tactile thresholds. This may help to further clarify the processes involved in determining tactile threshold. The effect of such manipulations on the relationship between tactile threshold, symptom reporting and health anxiety could also be investigated.

8.1.2.2. Somatic distortion

Differences between test-halves have not been reported (or obviously evaluated) in the majority of SSDT studies (Brown et al., 2010; Brown et al., 2013; Katzer et al., 2011). A recent study by Katzer et al., (2012) found a reduction in the tendency to experience somatic distortions (light-absent and light-present false alarms were averaged as the effect of the light was non-significant) in the second test-half. In each of the studies presented here there were non-significant and significant reductions in somatic distortions (in light-absent and light-present trials respectively) in the second test-half. The tendency to experience somatic distortions has previously been found to be a relatively stable trait-like characteristic (McKenzie et al., 2012); it may be that this characteristic is only measured reliably after initial practice on the task. It is also possible that experience of the task, that is, focusing on the body for a prolonged period of time under conditions of low perceptual load induces negative mood, which may increase the tendency to experience distortions, particularly in those already experiencing symptoms and health anxiety. Experimental evidence has shown that high trait NA and high symptom-reporting females make, when primed, more negative symptom attributions under conditions of low internal perceptual load. This finding has been interpreted as a tendency to rely on schema-driven interpretations of sensations, rather than bottom-up sensory information (Bogaerts et al., 2010). Further research taking pre- and post- SSDT mood and symptom measurements is needed to further explore this possibility, as well as investigating SSDT performance pre- and post- a negative mood induction.

For most participants the reduction in false alarms across the task led to improvements in tactile sensitivity. A recent study employed the SSDT before and after a period of brief body-scan mindfulness meditation training and found that the intervention reduced the tendency to experience somatic distortions, which improved tactile sensitivity (see Section 8.1.2.1; Mirams, et al., 2013) This study suggests that the nature of interoceptive attention affects the tendency to experience distortions in somatic awareness and may indicate why the tendency to experience distortions improves across the task for some participants, but not for others.

In Chapter 3, there was a near significant negative association between symptom reporting and somatic distortion in both light conditions on the second test-half, which yielded a medium sized effect. This relationship was in the opposite direction to that predicted. In Chapter 7, neither current nor retrospective symptom reporting was

significantly associated with somatic distortion. There was also a non-significant relationship between somatic distortion and health anxiety in Chapters 3 and 7. These finding are in contrast to previous SSDT studies, which have found positive associations between somatic distortion, symptom reporting (Brown et al., 2010; Brown et al., 2012, Katzer et al., 2011) and health anxiety (Katzer et al., 2013). It is noteworthy, however, that those SSDT studies that have found somatic distortion to be associated with symptom reporting had a greater range of symptom reporting than the studies described in Chapter 3 and 7. This suggests that the positive relationship between somatic distortion and symptom reporting may only apply for higher levels of symptom reporting. This hypothesis could be tested by recruiting high versus low symptom reporters and assessing the relationship between somatic distortion and symptom reporting within each group.

In Chapter 5, there were significant cross-sectional relationships between the tendency to experience somatic distortions, health anxiety and symptom reporting on the second test-half, but not the first test-half. These relationships were independent of relevant covariates and one another. Furthermore the sustained tendency to experience somatic distortions across test-halves was also independently associated with health anxiety and symptom reporting. Therefore with regards to symptom reporting, the effects seem to pertain specifically to 'functional somatisation' rather than to 'hypochondriachal somatisation' or 'presenting somatisation' (Kirmayer & Robbins, 1991). That is, the effect is not explained by concurrent health anxiety, trait anxiety, state anxiety or depression. With regards to health anxiety the observed effects pertain specifically to health anxiety and not to 'functional somatisation' or 'presenting somatisation'. This study adds to a growing evidence base which supports these relationships (Brown, et al., 2010; Katzer et al., 2011; Brown et al., 2012; Katzer et al., 2013). This finding therefore supports the model of MUS proposed by Brown (2004). Furthermore, the SEM analysis suggests that sustained somatic distortion is also an independent cross-sectional predictor of health care utilisation.

However, T1 somatic distortion was not a predictor of T2 health anxiety, symptom reporting or health care utilisation, when controlling for T1 outcome variables or covariates. Interestingly, both T1 symptom reporting and health anxiety were independent predictors of T2 somatic distortion, when controlling for T1 somatic distortion. The results of the primary care study therefore suggest that the tendency to experience distortions in somatic awareness may be a consequence, rather than a cause, of symptom reporting and health anxiety. Thus it appears that increased physical symptom reporting and health

anxiety may have consequences for the perceptual system, such that the experience of physical symptoms and health anxiety increase the tendency to erroneously identify the presence of a somatosensory stimulus when none has been given (i.e., a false alarm).

Biopsychosocial, cognitive attentional and neurobiological models would all predict that the tendency to experience distortions in somatic awareness is a risk factor for the development of physical symptoms and health anxiety; however, this has not been supported by the longitudinal results of the primary care study. These results do not support the idea that changes in somatic awareness are causative in the development of physical symptoms and health anxiety.

It is possible that a reciprocal relationship between somatic distortion, symptom reporting and health anxiety exists. Experiencing physical symptoms and health anxiety may mean that bottom-up perceptual information is found to be aversive or an unhelpful source of information about bodily state. This could mean that a preference for top-down information when making decisions about the presence or absence of somatosensory stimuli may develop; thus lowering the activation threshold of symptom representations in the cognitive system, which may maintain, or even increase, symptom reporting and health anxiety. Thus somatic distortion could be considered a maintenance factor for increased symptom reporting and health anxiety.

If such a reciprocal relationship exists then these results could indicate that developing treatments which target the tendency to experience distortions may improve health anxiety, symptom reporting and health care utilisation. Somatic distortions have been reduced in studies by increasing exteroceptive attention (Mirams et al., 2012), via perceptual training (McKenzie et al., 2012), and by body-scan meditation training (Mirams et al., 2013). However, further research is necessary to investigate whether such manipulations may simultaneously reduce health anxiety, symptom reporting and health care utilisation.

8.1.3. *Attention and somatic awareness*

Table 8.3 SSDT & MBT performance

Study	Population	Findings
Pilot study	Students	There was a negative association between visual disengagement and false alarms, although non-significant, this yielded a medium sized effect.
Primary care study	Primary care patients	At T2 less sensitive tactile thresholds were independently associated with delayed disengagement from threatening and neutral body-irrelevant material. There was no association between false alarms and attentional disengagement.
SEM analysis of primary care study data	Primary care patients	When data from both T1 & T2 were combined the sustained tendency to experience false alarms in light-absent trials was an independent positive predictor of symptom reporting, health anxiety and health care utilisation. The sustained tendency to experience light-present false alarms was an independent positive predictor of health anxiety, but not of symptom reporting or health care utilisation. A combined model, which included both attentional disengagement and light-absent false alarms, explained a greater proportion of the variance in symptom reporting, health anxiety and health care utilisation than a model which included attentional disengagement or false alarms alone.

The Brown model (2004) suggests that hypervigilance for the body, delayed disengagement from symptom relevant material, and a greater tendency to experience distortions in somatic awareness are causative factors in the development of MUS. We therefore wished to test the hypotheses that a model incorporating both attention to the body and somatic awareness would improve understanding of symptom reporting and health anxiety.

In Chapter 6, the SEM analysis suggested that a model which included hypervigilance, delayed disengagement and the sustained tendency to experience distortions explained a substantial part of the variance in symptom reporting, health anxiety and health care utilisation. This evidence provides additional support for the model of MUS proposed by Brown.

The Brown model, however, makes no claims about the relationship *between* delayed disengagement and somatic distortion. In contrast, the Rief and Barsky (2005) model suggests that increased attention to the body decreases a hypothesised filtering

mechanism. The models of Barsky and Wyshak (1990), and Pennebaker (1982) suggest that attention to the body increases the saliency of subtle somatosensory sensations and that this coupled with selective attention for illness consistent information increases symptom reporting. Thus, we also wished to test the hypotheses that increased attention to the body is associated with both increased somatic distortion and more sensitive tactile thresholds.

In the pilot study, a near significant negative relationship between attentional disengagement and somatic distortion was found, and this relationship yielded a medium sized effect. These results suggest that delayed disengagement is associated with a reduced tendency to experience somatic distortions. However, in the primary care study no such relationship was found between the tendency to experience distortions and attentional disengagement. The results of the primary care study do not support the results of the pilot study and suggest these findings may have been spurious.

In Chapter 5, it was found that less sensitive tactile thresholds on the SSDT were associated with poorer attentional disengagement on the MBT. This may indicate that poorer disengagement leads to a greater reliance on top-down information when making decisions about sensory experience. That is, those with poorer disengagement may attend away from the body or bottom-up information and this may lead to less sensitive tactile thresholds. These results suggest that treatments which increase attention to the body or to somatosensory information, such as, a body-scan meditation (Mirams et al., 2013) may simultaneously improve tactile sensitivity and attentional disengagement.

It is also possible that those with poorer disengagement in general may also have had poorer visual disengagement from the visual trial cues on the SSDT. This may reduce attention to the body, thus decreasing bottom-up information and increasing reliance on top-down information. Although the modality of start cue does not affect SSDT performance in healthy participants (McKenzie et al., 2010), it is possible that high health care utilisers have poorer disengagement from the visual trial start cues. Further SSDT studies with high health care utilisers should investigate whether the modality of the trial start cue affects subsequent performance, although poorer disengagement may be supramodal. It is, however, unlikely that there would be significant disengagement effects as there is an SOA of 500ms between the start cue and the presentation of the tactile stimulus.

8.1.4. *Negative affect*

Table 8.4 Negative mood induction findings

Study	Population	Findings
Mood and bodily symptoms study	Students	The negative mood induction was effective and increased negative mood. Increased negative mood in response to the induction was a unique positive predictor of increased post- induction symptom experience.

In Chapter 7, poorer mood in response to the negative mood induction was predictive of post-induction symptom development independently of age, gender, psychopathology (health anxiety, trait anxiety, state anxiety & depression) and pre-induction symptom experience. This finding provides evidence regarding the causative role acute negative emotional states play in the development of physical symptoms. Negative emotional states are thought to increase the likelihood of negative interpretations of ambiguous sensations, as well as increasing attention to the body or specific somatic experiences (Stegen, Van Diest, Van de Woestijne, & Van den Bergh, 2011; Wells & Matthews 1994; Gendolla, Anele, Andrei, Spurk & Richter, 2005). However, processes such as these were not measured post-induction and the processes that mediate the relationship between negative affect and symptom development therefore remain unclear.

These findings coupled with the significant findings for attentional disengagement in relation to body-relevant threat suggest that differences in attention and somatic awareness may only be apparent under conditions of threat (e.g. physical symptoms), or stress (e.g. negative affect), particularly in those with non-clinical levels of symptom reporting and health anxiety. Only those reporting clinical levels may display high levels of somatic distortion, more sensitive tactile thresholds, hypervigilance or delayed disengagement irrespective of mood state. Future research should examine individual differences in attention and somatic awareness and their relationship with symptom reporting and health anxiety, in response to threat or negative affect. This could be achieved by employing a negative mood induction as employed in the present research, or by using manipulations to induce physical symptoms such as enriched $C0_2$ inhalation (e.g. Schmidt & Trakowski, 2004).

8.2. Strengths, limitations and future directions

As discussed in Chapter 1, symptom reporting and health anxiety are considered to span a continuum of severity (Katon et al., 1991). The Brown model (2004) also predicts that differences in attention and somatic awareness exist on a continuum. As a result it has been hypothesised that individual differences in attention and somatic awareness are linearly related to symptom reporting and health anxiety. Therefore correlational designs have been employed throughout this research to investigate hypothesised relationships. Employing correlational designs has meant greater power to detect subtle associations; however, large numbers of participants are required. As a result the research presented here has focused on a pilot study followed by two large scale studies.

The results of the pilot study, and mood and bodily symptoms study, when compared with the results of the primary care study, were not simply a less extreme version of the relationships between somatic distortion, attention, symptom reporting and health anxiety. In the pilot study, there was a near significant negative relationship between somatic distortion and symptom reporting, whereas in the primary care study there were significant positive relationships. These contrasting results are inconsistent with a continuum hypothesis. Furthermore, in the pilot study in the neutral body-irrelevant condition, delayed attentional disengagement was associated with symptom reporting and enhanced disengagement was associated with health anxiety. In contrast, in the primary care study enhanced disengagement in the neutral body-irrelevant condition and delayed disengagement in the threatening body-relevant condition was associated with increased health care utilisation, but not symptom reporting or health anxiety. These findings are also inconsistent with a continuum hypothesis. In the mood and bodily symptoms study, however, the finding that there was a near significant relationship between post-induction symptom experience and the same pattern of effects as the primary care study is consistent with the continuum hypothesis.

It may be that the continuum hypothesis in relation to attentional and perceptual processes is limited. There may be a symptom reporting threshold at which attentional and perceptual processes change, rather than a strictly linear relationship. It is also possible that other factors which have not been measured here, such as trauma or acute illness, account for an important part of the relationship between attention, somatic awareness, symptom reporting and health anxiety. Further research is necessary to establish the reliability of these findings with a wide range of symptom reporting and health anxiety,

and to investigate other factors considered relevant to attention, somatic awareness, symptom reporting and health anxiety (e.g. trauma).

Another major strength of the research presented here lies in the primary care study, where a large clinical sample was recruited and a longitudinal design was implemented. Most individuals who report high numbers of physical symptoms and high health anxiety are seen in primary care. Thus, recruiting participants from primary care was considered to provide a sample which would be likely to demonstrate processes hypothesised to be relevant in such presentations. As noted in Chapter One, there is considerable debate regarding the processes involved in the development and maintenance of physical symptoms associated with conversion disorder, somatic symptom disorders and functional syndromes. Some authors have argued that similar processes underlie these, whilst others have argued that entirely different processes are responsible (see Brown, 2007, for a review of this issue). It is therefore difficult to know whether the findings of the research presented here can be generalised to other patient groups, such as, those with conversion disorders or functional syndromes. A previous SSDT study found that somatic distortion was associated with symptom reporting in patients recruited from an endoscopy clinic, irrespective of whether they had medically explained or unexplained bowel complaints (Brown et al., 2012). Future research could investigate the relationship between symptom reporting, health anxiety, attention and somatic awareness in patients with medically explained and unexplained neurological symptoms (e.g. patients with conversion disorder vs. patients with epilepsy). This may further elucidate whether patients with conversion disorders also demonstrate similar processes and whether the extent to which they report symptoms or are health anxious is more salient than the diagnostic status of their symptoms.

Although the theories discussed in Chapter One suggest that individual differences in attention and somatic awareness are causative factors in the development of physical symptoms, the majority of the research in this area has been cross-sectional in nature. It has therefore not been possible to infer causality. Another major strength of the primary care study was the use of a longitudinal design. The longitudinal analysis suggested that both hypervigilance and delayed disengagement may not be causally related to health care utilisation, symptom reporting or health anxiety. Furthermore, the tendency to experience somatic distortions may be a consequence, rather than a cause, of symptom reporting and health anxiety. This study, therefore suggests that while individual differences in attentional and perceptual processes maybe associated with symptom reporting, health

anxiety and health care utilisation, they may not be causative factors in their development as hypothesised by the biopsychosocial, cognitive attentional and neurobiological models discussed in this thesis (e.g. Rief & Barsky, 2005; Brown, 2004). However, longitudinal designs do not prove temporal precedence (Bollen, 1989). Thus studies employing experimental designs are required to definitively rule out/establish causal relationships.

8.3. Conclusions

The investigations of attention and the tendency to experience distortions in somatic awareness are linked by the model of MUS proposed by Brown (2004). In this model, MUS are caused by a tendency to place greater weight on top-down symptom representations in the creation of perception and are perpetuated by hypervigilance for the body and difficulties disengaging symptom-focused attention. The investigations of attention, tactile threshold and the tendency to experience distortions in somatic awareness are linked by biopsychosocial models (Barsky & Wyshak, 1990; Rief & Barsky, 2005), which suggest that attention to the body and other factors reduce the threshold at which sensations are perceived, increasing the likelihood of the misattribution of inert sensations as symptoms.

The evidence presented here suggests that complex attentional processes involving enhanced and delayed attentional disengagement maybe associated with health care utilisation possibly via another unknown variable. However, this evidence does not support the often-hypothesised general attentional bias for the body as a causative factor in health anxiety, symptom reporting and MUS. This research has provided important evidence about attentional differences and how future research might extend the findings reported here.

The evidence reported here has also supported the hypothesis that the tendency to experience distortions in somatic awareness is independently associated with both symptom reporting and health anxiety. These findings provide empirical support for theories which suggest MUS may be associated with altered somatic awareness (e.g., Barsky & Wyshak, 1990; Cioffi, 1991; Rief & Barsky, 2005) and a tendency to place greater weight on top-down factors in the creation of somatic awareness (e.g., Brown, 2004; Edwards et al., 2013).

However, these results do not seem to suggest that an increased tendency to experience distortions in somatic awareness is a cause of increased symptom reporting or

health anxiety. Indeed it seems that increased symptom reporting and health anxiety may be causes of increased somatic distortion. That is experiencing physical symptoms and health anxiety appears to have effects upon perceptual decision making, such that, erroneously identifying the presence of a somatosensory stimulus when none has been given (i.e., false alarms) increases. The implications of this finding are that whilst alterations in somatic awareness may be a maintenance factor for symptom reporting and health anxiety, somatic distortion does not appear to be a causative factor in their development.

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Appendix A: Questionnaires

Health care utilisation questionnaire

This section asks about your use of different health services in the last SIX MONTHS. Please think carefully about the last six months and answer the questions accordingly in BLOCK CAPITALS. Don't worry if you are not 100% certain of the exact details in each case - please just give us your best estimate. Please do not hesitate to contact the study researcher for help if needed.

Part 1. Health care use

1. How many times in *the last six months* have you visited your GP?

_____

2. How many times in *the last six months* have you visited your practice nurse?

_____

3. How many times in *the last six months* have you visited your dentist?

_____

4. In *the last six months* have you visited any other practitioner at your GP surgery? **Yes ☐ No ☐**
If so please specify their job title below and how many times you have seen them in the *last six months*.

_____
_____
_____
_____

5. How many times in *the last six months* has your GP visited you at home?

_____

6. How many times in *the last six months* have you visited a hospital Accident & Emergency department?

_____

7. Have you been treated in hospital in *the last six months*? **Yes ☐ No ☐**

a. If yes, then how many times have you been an in-patient in the last six months?_____
_____
_____

b. And how long were you an in-patient for each time (If more than once please indicate e.g. Visit 1: 3 days; Visit 2: 4 days)?
_____
_____
_____

8. Have you been an out-patient at hospital? **Yes ☐ No ☐**
a. If yes, how many appointments in *the last six months* have you had at hospital as an out-patient?
_____

9. This question concerns your use of other health care services . If you have used any of the services listed below in *the last six months* then please tick the corresponding box and indicate how many appointments you have had (or, for inpatient stays, how long it lasted) in the column on the right.

	Tick all that apply	Number of Appointments / how long in the last six months?
Optician	☐	_____
Pharmacist	☐	_____
Private doctor/consultant	☐	_____
Private hospital as an inpatient	☐	_____
Private hospital as an outpatient	☐	_____
Emergency doctor's clinic	☐	_____
NHS walk in centre	☐	_____
Sexual health clinic	☐	_____
Mental health clinic	☐	_____
Dental hospital	☐	_____
Midwife	☐	_____
Physiotherapist	☐	_____
Speech and language therapist	☐	_____
Occupational health visitor	☐	_____
Health visitor	☐	_____

Chiropractor	☐	_____
Osteopath	☐	_____
Complementary practitioner (e.g. Acupuncture)	☐	_____
Psychotherapist	☐	_____
Other: _____		_____
_____		_____

Part 2. Medication

Are you currently taking any prescribed medication? **Yes ☐ No ☐**

If yes what are the names of the medication(s)?

_____
_____
_____
_____
_____

2. Have you been prescribed any medication in *the last six months* that you
are not currently taking now? **Yes ☐ No ☐**
If yes what type of medication was it? And how long were you taking it for?

_____
_____

3. Roughly how much have you spent on your prescriptions in *the last six months*? If you use a prepayment card please state whether it is 3 monthly, 6 monthly or
yearly?_____

_____
_____
_____

4. Have you taken any over-the-counter medicines in *the last six months* (e.g. ibuprofen, antihistamines)? **Yes ☐ No ☐**
If so what are they
called?_____

_____
_____
_____

5. Roughly how much have you spent in *the last six months* on over the counter medications (things like ibuprofen/paracetamol/ antihistamines)?

_____
_____
_____
_____

Demographics Questionnaire
PLEASE READ THE FOLLOWING CAREFULLY:
Please either insert your answer or tick the box (☑) that best describes you. Please write your answers in block CAPITALS.

DOB: DD/MM /YYYY **Sex**: M: ☐, F: ☐
Ethnicity: White British: ☐, White Irish: ☐,
White other please
specify:_____
Black British: ☐, Black African: ☐, Black Caribbean: ☐,
Black other please
specify:_____
Asian British: ☐, Asian other, please specify:_____
Chinese British: ☐, Chinese other, please specify:_____
Other please specify:
_____
Refusal to specify: ☐

Marital status: Single: ☐, Married/civil partnership: ☐, Cohabiting: ☐
Divorced/separated: ☐, Widowed: ☐, Refusal to specify: ☐

Education: Which of these qualifications do you have? Please tick all that apply, or if not specified the nearest equivalent:
No Qualifications: ☐
1+ O Level/ CSEs/GCSEs (any grade): ☐
NVQ Level 1, Foundation GNVQ: ☐
5+ O Levels, 5+ GCSEs (grades A-C), School Certificate: ☐
NVQ Level 2, Intermediate GNVQ: ☐,
1+ A Level/ AS levels: ☐
Higher 2+ A Levels, 4+ AS Levels, Higher School Certificate: ☐
NVQ Level 3, Advanced GNVQ: ☐,
First Degree (e.g. BA, BSc): ☐
Other qualifications (e.g. City and Guilds, RSA/OCR, BTEC/Edexcel): ☐
Higher Degree (e.g. MA, PhD, PGCE, post-graduate certificate/diplomas): ☐

Employment:
Employed: ☐, Full time: ☐, part time: ☐
Self-employed: ☐, full time: ☐, part time: ☐
Unemployed: ☐
Student: ☐, Part time: ☐, Full time:☐
Retired: ☐, Medically retired: ☐

Mood Rating Scale

Please rate how you are feeling ***at the present moment*** for each of the questions below by drawing a line on each scale. Please give your immediate response (gut reaction) rather than thinking about each item in great detail.

For example:

Not at all anxious **Extremely anxious**

0 **10**

*Q1. How **anxious** are you right now?*

Not at all anxious **Extremely anxious**

0 **10**

*Q2. How **depressed** are you right now?*

Not at all depressed **Extremely depressed**

0 **10**

*Q3. How **disgusted** are you right now?*

Not at all disgusted **Extremely disgusted**

0 **10**

Modified Symptom checklist

No headache											Headache
No watering eyes											Watering eyes
No congested nose											Congested nose
No racing heart											Racing heart
No upset stomach											Upset stomach
No flushed face											Flushed face
No tense muscles											Tense muscles
No sweaty hands											Sweaty hands
No shortness of breath											Shortness of breath
No cold hands											Cold hands
No dizziness											Dizziness
No ringing in ears											Ringing in ears
No pain											Pain
No fatigue											Fatigue

Appendix B: Supplementary analysis for pilot study

B.1. Data analysis

Data were screened for normality; non-normal data and their transformations are displayed in Table B.1 below.

Table B. 1 Non-normally distributed variables from the pilot study and their transformations.

Variable	**Kolmogorov -Smirnov**	***p***	**Transformation**	**Kolmogorov -Smirnov**	***p***
- Age	.198	.008	Log	.162	.068
Questionnaires					
- PHQ-9	.230	.001	Log	.157	.085
- HAI	.184	.020	Log	.125	.200
MBT					
Picture threat ratings					
-Neutral-body	.321	.000	-	-	-
-Neutral-scene	.403	.000	-	-	-
Tactile bias					
-Threat-body	.193	.011	Outlier corrected	.142	.175
SSDT					
- Threshold vibration 1	.180	.036	-	-	-
- Threshold vibration 2	.255	.000	-	-	-
Block 1					
Light-absent					
- Hits	.179	.039	-	-	-
- False alarms	.245	.000	-	-	-
Block 2					
Light-absent					
- False alarms	.265	.000	-	-	-
Light-present					
- Hits	.210	.006	-	-	-
- False alarms	.255	.000	-	-	-

B.2. Hierarchical regressions predicting symptom reporting and health anxiety from MBT performance

Symptom reporting

Table B.2 below displays the results of four separate hierarchical regressions, each taking PHQ-15 as the target variable and visual performance in each of the picture conditions as predictors in step 2, and with covariates (age, gender, HAI, STAI-T, STAI-S, PHQ-9) in step 1. The inclusion of visual performance in the neutral-scene condition led to

a significant increase in the predictive power of the regression equation*)* and enhanced the predictive power of health anxiety such that it was also a significant unique predictor. The inclusion of visual performance in the other picture conditions did not lead to a significant increase in the power of the regression equation.

Table B. 2 *Hierarchical multiple-regression analysis predicting symptom reporting from visual performance in each of the picture conditions controlling for: age, gender, health anxiety, trait anxiety, state anxiety and depression (n = 27).*

Symptom reporting												
	Model 1			Model 2			Model 3			Model 4		
Variable	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Constant	-12.85	6.86	-	-11.88	6.37	-	15.25	6.787	-	-15.48	7.09	-
Age	5.00	5.20	.20	1.98	5.09	.08	6.48	4.86	.26	7.27	5.03	.29
Gender	1.15	0.97	.21	1.20	0.88	.23	1.59	0.94	.30	1.39	0.98	.26
HAI	6.16	3.70	.38	7.57	3.50	.47*	5.72	3.58	.36	5.06	3.69	.31
STAI-T	-0.05	0.09	-.15	-0.03	0.08	-.11	-0.03	0.09	-.09	-0.02	0.09	-.08
STAI-S	-0.05	0.07	-.18	-0.06	0.06	-.23	-0.05	0.07	-.18	-0.06	0.07	-.21
PHQ-9	3.42	2.41	.34	2.84	2.23	.28	2.88	2.40	.28	3.34	2.48	.33
Visual targets						.						.
Neutral body	0.01	0.00	.42	-	-	-	-	-	-	-	-	-
Neutral scene	-	-	-	0.01	0.00	.57*	-	-	-	-	-	-
Threat body	-	-	-	-	-	-	0.01	0.00	.39	-	-	-
Threat scene	-	-	-	-	-	-	-	-	-	0.01	0.01	.31
ΔR^2 (P)	.11 (.07)			.19 (.01)			.12 (.06)			.07 (.14)		

*p < .05. ** p < .001.

Table B.3 below displays the results of three separate hierarchical regressions taking PHQ-15 as the target variable and visual performance in neutral-body, threat-body and threat-scene conditions as predictors in step 2, and with covariates (age, gender, HAI, STAI-T, STAI-S, PHQ-9 and neutral-scene visual performance) in step 1. None of the predictors led to a significant improvement in the predictive power of the regression equation.

Table B. 3 *Hierarchical multiple-regression analysis predicting symptom reporting from visual performance in each of the picture conditions controlling for: age, gender, health anxiety, trait anxiety, state anxiety, depression and general task performance (n = 27).*

Symptom reporting									
	Model 1			Model 2			Model 3		
Variable	B	SE B	β	B	SE B	β	B	SE B	β
Constant	-11.61	6.36	-	-12.16	6.75	-	-9.91	6.83	-
Age	1.08	5.15	-.04	2.15	5.33	.09	.68	5.36	.03
Gender	1.42	0.91	.27	1.23	.92	.23	1.21	.89	.23
HAI	7.76	3.50	.48*	7.55	3.59	.47*	7.95	3.55	.49*
STAI-T	-0.01	0.09	-.03	-0.04	0.08	-.11	-0.03	0.08	-.10
STAI-S	-0.07	0.07	-.25	-0.06	0.07	-.22	-0.06	0.07	-.20
PHQ-9	2.32	2.28	.23	2.82	2.29	.28	2.64	2.26	.26
Visual targets									
Neutral-scene	.02	0.01	1.05*	0.01	0.01	.54	0.02	0.01	.81*
Neutral-body	-.01	0.01	-.51	-	-	-	-	-	-
Threat-body	-	-	-	.00	.01	.04	-	-	-
Threat-scene	-	-	-	-	-	-	-0.01	0.01	-.26
ΔR^2 *(P)*	.03 (.31)			.00 (.87)			.02 (.41)		

*p <.05. ** p <.001.

The analysis conducted for visual performance was repeated for tactile performance. Table B.4 below displays the results of the regression analysis. The inclusion of tactile performance in the threat-scene condition led to a significant increase in the predictive power of the regression equation. The inclusion of tactile performance in the other picture conditions did not lead to a significant increase in the power of the regression equation.

Table B. 4 *Hierarchical multiple-regression analysis predicting symptom reporting from tactile performance in each of the picture conditions, controlling for: age, gender, health anxiety, trait anxiety, state anxiety and depression (n = 27).*

Symptom reporting												
	Model 1			Model 2			Model 3			Model 4		
Variable	B	SEB	β	B	SEB	β	B	SEB	β	B	SEB	β
Constant	-18.12	7.36	-	-18.44	7.44	-	-16.58	7.74	-	-17.92	6.98	-
Age	7.78	4.90	.31	8.48	4.83	.34	9.02	5.04	.36	6.41	4.86	.25
Gender	1.63	.97	.30	1.48	.97	.28	1.47	1.02	.27	1.78	.94	.33
HAI	6.54	3.98	.41	6.49	3.98	.40	5.06	4.08	.31	6.87	3.77	.43
STAI-T	-0.04	0.09	-.12	-0.03	0.09	-.10	-0.02	0.10	-.06	-0.05	0.09	-.17
STAI-S	-0.06	0.07	-.21	-0.06	0.07	-.21	-0.05	0.08	-.18	-0.04	0.07	-.14
PHQ-9	2.98	2.48	.29	3.09	2.47	.30	3.14	2.59	.31	3.03	2.39	.30
Tactile targets												
Neutral-body	.01	0.01	.34	-	-	-	-	-	-	-	-	-
Neutral-scene	-	-	-	.01	0.01	.33	-	-	-	-	-	-
Threat-body	-	-	-	-	-	-	.00	0.00	.19	-	-	-
Threat-scene	-	-	-	-	-	-	-	-	-	0.01	0.01	.42*
ΔR^2 (P)	.08 (.12)			.08 (.12)			.03 (.38)			.12 (.05)		

*p <.05. ** p <.001.

Table B.5 below displays the results of three separate hierarchical regressions taking PHQ-15 as the target variable and tactile performance in neutral-body, threat-body and threat-scene conditions as predictors in step 2, and with covariates (age, gender, HAI, STAI-T, STAI-S, PHQ-9 and neutral-scene tactile performance) in step 1. None of the

predictors led to a significant improvement in the predictive power of the regression equation.

Table B. 5 *Hierarchical multiple-regression analysis predicting symptom reporting from tactile performance in each of the picture conditions controlling for: age, gender, health anxiety, trait anxiety, state anxiety and depression and general task performance (n = 27).*

Symptom reporting									
	Model 1			Model 2			Model 3		
Variable	B	SEB	β	B	SEB	β	B	SEB	β
Constant	-18.64	7.60	-	-18.11	7.33	-	17.13	7.43	-
Age	7.99	5.02	.32	8.18	4.76	.32	5.72	5.28	.23
Gender	1.55	1.00	.29	1.72	.97	.32	1.92	1.02	.36
HAI	6.80	4.10	.42	6.45	3.91	.40	6.59	3.93	.41
STAI-T	-0.04	0.09	-.12	-0.03	0.09	-.09	-0.06	0.09	-.18
STAI-S	-0.06	0.08	-.21	-0.06	0.07	-.21	-0.03	0.08	-.10
PHQ-9	3.00	2.53	.30	3.32	2.44	.33	3.05	2.44	.30
Tactile targets									
Neutral-scene	0.00	0.01	.17	0.02	0.01	.87	-0.00	0.01	-.18
Neutral-body	0.01	0.01	.20	-	-	-	-	-	-
Threat- body	-	-	-	-0.01	0.01	-.59	-	-	-
Threat-scene	-	-	-	-	-	-	0.02	0.01	.59
ΔR^2 (*P*)	.01 (.61)			.05 (.22)			.04 (.24)		

*p <.05. ** p <.001.

Health anxiety

The analysis above was repeated, but this time taking health anxiety as the target variable and performance in each of the picture conditions as predictors in step 2, and with covariates (age, gender, PHQ-15, STAI-T, STAI-S and PHQ-9) in step 1. Table B.6 below displays the results of the regressions taking visual performance as predictors. The addition of visual performance in the neutral-scene and neutral-body conditions significantly improved the predictive power of the regression equation. Furthermore when visual performance in the neutral-scene condition was entered as a predictor, symptom reporting also became a unique positive predictor.

Table B. 6 *Hierarchical multiple-regression analysis predicting health anxiety from visual performance in each of the picture conditions controlling for: age, gender, symptom reporting, trait anxiety, state anxiety and depression.*

Health anxiety (*n* = 27)												
	Model 1			Model 2			Model 3			Model 4		
Variable	B	SEB	β	B	SEB	β	B	SEB	β	B	SEB	β
Constant	0.72	0.40	-	0.68	0.38	-	0.90	0.41	-	0.91	0.42	-
Age	0.13	0.31	.09	0.24	0.30	.15	0.02	0.31	.01	0.01	0.31	0.01
Gender	0.01	0.06	.02	-0.01	0.05	-.03	-0.02	0.06	-.07	-0.01	0.06	-0.02
PHQ-15	0.02	0.01	.33	0.03	0.01	.42*	0.02	0.01	.33	0.02	0.01	0.29
STAI-T	0.00	0.01	.21	0.00	0.01	.16	0.00	0.01	.14	0.00	0.00	0.14
STAI-S	0.01	0.00	.35	0.01	0.00	.38	0.01	0.00	.37	0.01	0.00	0.41
PHQ-9	0.05	0.15	.08	0.05	0.14	.08	0.09	0.15	.14	0.08	0.15	0.12
Visual targets						.			-			.
Neutral-body	-0.00	0.00	-.45*	-	-	-	-	-	-	-	-	-
Neutral-scene	-	-	-	-0.00	0.00	-.57*	-	-	-	-	-	-
Threat-body	-	-	-	-	-	-	0.00	0.00	-.36	-	-	-
Threat-scene	-	-	-	-	-	-	-	-	-	0.00	0.00	-.32
ΔR^2 (*P*)	.13 (.03)			.19 (.01)			.10 (.07)			.08 (.12)		

*p <.05. ** p <.001.

Table B.7 below displays the results of the regressions controlling for neutral-scene performance. The addition of visual performance in the neutral-body, threat-body and threat-scene performance did not lead to a significant improvement in the regression equation.

Table B. 7 *Hierarchical multiple-regressions predicting health anxiety from visual performance in each of the picture conditions controlling for: age, gender, symptom reporting, trait anxiety, state anxiety, depression and general task performance (n = 27).*

Health anxiety									
	Model 1			Model 2			Model 3		
Variable	B	SE B	β	B	SE B	β	B	SE B	β
Constant	.68	.38	-	.67	.40	-	.56	.40	-
Age	.27	.30	.17	.25	.31	.16	.31	.31	.20
Gender	-.02	.06	-.06	-.01	.06	-.03	-.01	.06	-.04
PHQ-15	.03	.01	.45*	.03	.01	.42*	.03	.01	.44*
STAI-T	.00	.00	.10	.00	.01	.16	.00	.01	.14
STAI-S	.01	.00	.39	.01	.00	.38	.01	.04	.35
PHQ-9	.06	.14	.10	.05	.14	.08	.05	.14	.09
Visual targets									
Neutral-scene	-.00	.00	-.88*	-.00	.00	-.58	-.00	.00	-.80*
Neutral-body	.00	.00	.32	-	-	-	-	-	-
Threat-body	-	-	-	1.59	.00	.02	-	-	-
Threat-scene	-	-	-	-	-	-	.00	.00	.25
ΔR^2 (*P*)	.01 (.51)			.00 (.96)			.17 (.40)		

*p <.05. ** p <.001.

The analyses conducted for visual performance was repeated for tactile performance. Table B.8 below displays the results taking tactile performance as the predictors. Tactile performance in each of the picture conditions was a significant unique predictor of health anxiety.

Table B. 8 *Hierarchical multiple-regressions predicting health anxiety from tactile performance in each of the picture conditions controlling for: age, gender, symptom reporting, trait anxiety, state anxiety and depression.*

Health anxiety (*n* =27)												
	Model 1			Model 2			Model 3			Model 4		
Variable	B	SEB	β	B	SEB	β	B	SEB	β	B	SEB	β
Constant	1.06	0.39	-	1.08	0.39	-	1.01	0.40	-	1.04	0.39	-
Age	-0.01	0.28	-.01	-0.07	0.28	-.04	-0.05	0.29	-.03	0.04	0.28	.03
Gender	-0.02	0.06	-.07	-0.01	0.06	-.04	0.00	0.06	.01	-0.04	0.06	-.12
PHQ-15	0.02	0.01	.31	0.02	0.01	.31	0.02	0.01	.24	0.02	0.01	.35
STAI-T	0.00	0.01	.20	0.00	0.01	.18	0.00	0.01	.16	0.00	0.01	.23
STAI-S	0.01	0.00	.37	0.01	0.00	.37	0.01	0.00	.37	0.01	0.00	.29
PHQ-9	0.08	0.14	.12	0.07	0.14	.11	0.10	0.14	.16	0.06	0.14	.10
Tactile targets				-		-				-		
Neutral-body	-0.00	0.00	-.45*	-	-	-	-	-	-	-	-	-
Neutral-scene	-	-	-	-0.00	0.00	-.44*	-	-	-	-	-	-
Threat-body	-	-	-	-	-	-	-0.00	0.00	-.38*	-	-	-
Threat-scene	-	-	-	-	-	-	-	-	-	-0.00	0.00	-.47*
ΔR^2 (*P*)	.18 (.01)			.17 (.01)			.13 (.03)			.17 (.01)		

*p <.05. ** p <.001.

Table B.9 below displays the results of the regressions taking neutral-scene performance as a covariate. The addition of tactile performance in neutral-body, threat-body and threat-scene conditions did not lead to a significant increase in the predictive power of the regression equation.

Table B. 9 *Hierarchical multiple-regressions predicting health anxiety from tactile performance in each of the picture conditions controlling for: age, gender, symptom reporting, trait anxiety, state anxiety, depression and general task performance (n = 27).*

Health anxiety									
	Model 1			Model 2			Model 3		
Variable	B	SEB	β	B	SEB	β	B	SEB	β
Constant	1.09	0.39	-	1.10	0.40	-	1.07	0.40	-
Age	-0.04	0.29	-.02	-0.08	0.29	-.05	-0.02	0.30	-.01
Gender	-0.02	0.06	-.06	-0.02	0.06	-.06	-0.03	0.06	-.08
PHQ-15	0.02	0.01	.31	0.02	0.01	.33	0.02	0.01	.33
STAI-T	0.00	0.01	.20	0.00	0.00	.18	0.00	0.01	.21
STAI-S	0.01	0.00	.37	0.01	0.00	.38	0.01	0.00	.33
PHQ-9	0.07	0.14	.11	0.06	0.14	.09	0.06	0.14	.10
Tactile targets									
Neutral-scene	0.00	0.00	-.23	-0.00	0.00	-.61	0.00	0.00	-.24
Neutral-body	0.00	0.00	-.25	-	-	-	-	-	-
Threat-body	-	-	-	0.00	0.00	.18	-	-	-
Threat-scene	-	-	-	-	-	-	0.00	0.00	-.23
ΔR^2 (*P*)	.01 (.45)			.00 (.69)			.01 (61)		

*p <.05. ** p <.001.

B.3. Zero-order correlations between SSDT performance, symptom reporting and health anxiety

Table B.10 and B.11 below, display zero-order correlations between SSDT performance and sample characteristics. There was a significant correlation between gender and tactile sensitivity with women having greater sensitivity than men. There were no other significant correlations.

Table B. 10 Zero-order correlations between: block 1 SSDT parameters in light-absent and light-present conditions, demographics and questionnaire measures (n = 27).

	Light-absent				**Light-present**			
	Hits	False alarms	*d'*	*c*	Hits	False alarms	*d'*	*c*
Age	-.32	-.08	-.14	.21	-.10	.06	-.12	.05
Gender	.39	-.19	.40*	-.24	.37	-.21	.37	-.08
PHQ-15	.05	-.28	.13	.15	.16	-.20	.15	.06
HAI	-.30	-.01	-.15	.22	.02	.20	-.01	-.15
STAI-T	-.06	.03	-.08	-.02	.17	.02	.18	-.25
STAI-S	-.03	-.07	-.03	.11	.31	-.07	.22	-.20
PHQ-9	-.14	-.12	.04	.13	.19	-.09	.31	-.15

Table B. 11 Zero-order correlations (Pearson's and Spearman's) between: block 2 SSDT parameters in light-absent and light-present conditions, demographics and questionnaire measures (n = 27).

	Light-absent				**Light-present**			
	Hits	False alarms	*d'*	*c*	Hits	False alarms	*d*'	*c*
Age	-.25	-.17	-.03	.31	.06	.26	-.12	-.26
Gender	.01	-.03	.09	-.03	.07	-.14	.07	.16
PHQ-15	.17	-.33	.30	.06	.06	-.35	.27	.16
HAI	-.12	-.08	.09	.25	-.09	.08	-.04	-.02
STAI-T	.01	-.27	.20	.17	.05	.04	.00	-.15
STAI-S	-.02	-.31	.22	.22	-.01	.10	-.11	-.19
PHQ-9	.37	-.11	.39	-.22	.31	-.03	.31	-.24

B.4. Hierarchical regressions predicting symptom reporting and health anxiety from SSDT performance

Table B.12 below displays the results of four separate hierarchical regressions, each taking PHQ-15 as the target variable and false alarm variables as predictors in step 2, and with covariates (age, gender, HAI, STAI-T, STAI-S, PHQ-9) in step 1. The results of the regression analysis revealed there were no significant relationships between false alarms, and symptom reporting when controlling for relevant covariates.

Table B. 12 Hierarchical multiple-regressions predicting symptom reporting from blocks 1 and 2 light-absent and present false alarms controlling for: age, gender, health anxiety, trait anxiety, state anxiety and depression (n = 27).

Symptom reporting												
	Model 1			Model 2			Model 3			Model 4		
Variable	B	SE B	β	B	SE B	β	B	SEB	β	B	SE B	β
Constant	-12.88	8.18	-	-14.49	7.74	-	-11.32	8.07	-	-14.43	7.37	-
Age	8.72	5.53	.34	9.56	5.35	.37	8.77	5.30	.34	9.74	5.10	.38
Gender	1.52	1.11	.28	1.47	1.10	.27	1.60	1.07	.29	1.44	1.04	.26
HAI	3.10	4.07	.19	4.13	4.08	.25	2.53	4.01	.16	3.20	3.81	.20
STAI-T	0.03	0.11	.08	0.01	0.10	.03	-0.01	0.10	-.03	0.01	0.10	.03
STAI-S	-0.05	0.09	-.17	-0.05	0.09	-.15	-0.05	0.09	-.17	-0.01	0.09	.03
PHQ-9	2.66	3.00	.26	2.62	2.86	.26	3.42	2.69	.34	2.46	2.66	.24
False alarms									-			
Block 1												
Light-absent	-2.98	4.91	-.14	-	-	-	-	-	-	-	-	-
Light-present	-	-	-	-2.97	3.40	-.18	-	-	-	-	-	-
Block 2												
Light-absent	-	-	-	-	-	-	-5.01	4.41	-.24	-	-	-
Light-present	-	-	-	-	-	-	-	-	-	-4.95	3.08	-.32
ΔR^2 (*P*)	.01 (.55)			.028 (.40)			.05 (.27)			.09 (.13)		

*p <.05. ** p <.001.

Table B.13 below displays the results of four separate hierarchical regressions, each taking HAI as the target variable and false alarm variables as predictors in step 2, and with

covariates (age, gender, HAI, STAI-T, STAI-S, PHQ-9) in step 1. The results of the regression analysis revealed there were no significant relationships between false alarms, and health anxiety when controlling for relevant covariates.

Table B. 13 Hierarchical multiple-regression analyses predicting health anxiety from blocks 1 and 2 light-absent and present false alarms controlling for covariates (n = 27).

Health anxiety												
	Model 1			Model 2			Model 3			Model 4		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	0.81	0.47	-	0.78	0.45	-	0.82	0.47	-	0.79	0.47	-
Age	-0.06	0.35	-.04	-0.07	0.34	-.05	-0.04	0.34	-.02	-0.05	0.35	-.03
Gender	-0.02	0.07	-.05	-0.01	0.07	-.03	-0.01	0.07	-.03	-0.01	0.07	-.04
PHQ-15	0.01	0.01	.17	0.01	0.01	.23	0.01	0.01	.15	0.01	0.02	.20
STAI-T	0.00	0.01	.16	0.00	0.01	.04	0.00	0.01	.09	0.00	0.01	.10
STAI-S	0.01	0.01	.36	0.01	0.01	.39	0.01	0.01	.35	0.01	0.01	.37
PHQ-9	0.08	0.18	.13	0.14	0.17	.22	0.11	0.17	.18	0.11	0.17	.17
FAs		.								.		
Block 1												
Light-absent	-0.11	0.29	-.08	-	-	-	-	-	-	-	-	-
Light-present	-	-	-	0.20	0.19	.20	-	-	-	-	-	-
Block 2												
Light-absent	-	-	-	-	-	-	-0.16	0.27	-.12	-	-	-
Light-present	-	-	-	-	-	-	-	-	-	0.04	0.21	.04
ΔR^2 (*P*)	.01 (.71)			.04 (.31)			.01 (.56)			.00 (.87)		

*p <.05. ** p <.001.

Appendix C: Supplementary analysis for primary care study - MBT results

C.1. Data analysis

T1 and T2 data were screened for normality; non-normal data and their transformations are displayed in Table C.1 and C.2 below.

Table C. 1 T1 non-normally distributed variables from the primary care study and their transformations.

Variable	Shapiro-Wilk *W*	*P*	Transformation	Shapiro-Wilk *W*	*p*
Age	.89	.000	Unable to transform		
PHQ-15	.92	.000	Square root	.98	.18
HCU	.71	.000	Log	.99	.89
HAI	.97	.011	Log	.98	.06
BSI-Anx	.87	.000	Unable to transform		
BSI-Dep	.88	.000	Unable to transform		
Picture threat ratings					
-Neutral body	.69	.000	Unable to transform		
-Neutral scene	.52	.000	Unable to transform		
-Threat-body	.97	.017	Unable to transform		
-Threat-scene	.94	.000	Unable to transform		
Visual targets					
-Neutral-body	.94	.000	Log	.99	.41
-Threat-body	.94	.000	Log	.98	.17
-Threat-scene	.97	.014	Log	.99	.88
Tactile targets					
-Neutral-body	.92	.000	Log	.98	.07
-Neutral-scene	.92	.000	Log	.98	.15
-Threat-body	.93	.000	Log	.98	.12
-Threat-scene	.94	.000	Log	.99	.41
Tactile bias					
-Neutral scene	.97	.023	Unable to transform		
-Threatening scene	.96	.004	Unable to transform		

Table C. 2 T2 non-normally distributed variables from the primary care study and their transformations.

Variable	Kolmogorov-Smirnov	*p*	Transformation	Kolmogorov-Smirnov	*p*
Age	.19	.000	Unable to transform		
PHQ-15	.15	.001	Square root	.093	.200
HCU	.16	.000	Log	.103	.073
HAI	.13	.008	Square root	.082	.200
BSI-Anx	.18	.000	Unable to transform		
BSI-Dep	.17	.000	Unable to transform		
Picture threat ratings					
-Neutral body			Unable to transform		
-Neutral scene			Unable to transform		
-Threatening body			Unable to transform		
-Threatening scene			Unable to transform		
Visual targets					
-Neutral body	.15	.000	Log	.11	.055
-Neutral scene	.13	.000		.09	.200
-Threatening body	.15	.001	Log	.11	.045
-Threatening scene	.15	.001	Log	.11	.058
Tactile targets					
-Neutral scene	.12	.018	Log	.09	.200
-Threatening body	.11	.039	Log	.07	.200
-Threatening scene	.13	.006	Log	.09	.200

C.2. T1& T2: Bivariate analysis of MBT performance

There were large zero-order correlations between tactile and visual target performance in each of the stimulus conditions at both T1 and T2. This suggests that performance was similar regardless of target modality, picture valence and picture type (see Table C.3 and Table C.4 below).

Table C. 3 *T1 zero-order correlations between tactile and visual target performance (IE) in each of the stimulus conditions.*

	Tactile Targets				Visual Targets			
	Neutral-body	Neutral-scene	Threat-body	Threat-scene	Neutral-body	Neutral-scene	Threat-body	Threat-scene
Tactile Targets								
Neutral-body	-	.927**	.870**	.906**	.829**	.818**	.826**	.803**
Neutral-scene		-	.894**	.929**	.827**	.822**	.833**	.809**
Threat-body			-	.894**	.777**	.778**	.818**	.789**
Threat-scene				-	.831**	.803**	.827**	.814**
Visual Targets								
Neutral -body					-	.888**	.867**	.907**
Neutral-scene						-	.874**	.887**
Threat-body							-	.851**

*p <.05. ** p <.001.

Table C. 4 *T2 zero-order correlations (Pearson's) between tactile and visual target performance (IE) in each of the stimulus conditions.*

	Tactile Targets				Visual Targets			
	Neutral-body	Neutral-scene	Threat-body	Threat-scene	Neutral-body	Neutral-scene	Threat-body	Threat-scene
Tactile Targets								
Neutral-body	-	.948**	.906**	.931**	.882**	.852**	.871**	.875**
Neutral-scene		-	.919**	.945**	.877**	.867**	.859**	.877**
Threat-body			-	.924**	.866**	.876**	.871**	.861**
Threat-scene				-	.878**	.862**	.853**	.890**
V*isual Targets*								
Neutral-body					-	.921**	.944**	.953**
Neutral-scene						-	.927**	.908**
Threat-body							-	.934**

*p <.05. ** p <.001.

C.3. T1: Hierarchical multiple regression analyses

Table C.5 below displays the results of four separate hierarchical regressions, each taking PHQ-15 as the target variable and visual and tactile performance in the neutral-scene picture condition as predictors in step 2, and with covariates (age, gender, HAI, STAI-T, STAI-S, PHQ-9) in step 1. The inclusion of visual and tactile performance did not lead to a significant increase in the predictive power of the regression equation.

Table C. 5 *Hierarchical multiple regression analyses predicting T1 symptom reporting from T1 tactile and visual performance in the neutral scene condition of the modality bias task, controlling for age, gender, medical conditions (CCI), NA (STAI-T), health anxiety (HAI), anxiety (BSI-A), depression (BSI-D).*

T1: Symptom reporting (*n* =104)						
	Model 1		Model 2		Model 3	
Variable	*β*	*p*	*β*	*p*	*β*	*p*
Constant	-	.082	-	.955	-	.326
Age	.00	.959	-.00	.977	-.01	.861
Gender	.26	.001*	.25	.002*	.25	.002*
CCI	.25	.001*	.24	.003*	.23	.004*
HAI	.20	.022*	.20	.021*	.20	.018*
STAI-T	.15	.133	.15	.140	.15	.135
BSI-A	.30	.005*	.30	.005*	.30	.004*
BSI-D	.14	.240	.13	.265	.12	.308
Neutral scene						
- Tactile	-	-	.04	.61	-	-
- Visual	-	-	-	-	.07	.398
ΔR^2 (*p*)	.51	(.000)*	.00	(.606)	.00	(.398)

The analysis conducted above was repeated with health care utilisation as the dependent variable. Gender and health anxiety were unique predictors of health care utilisation. Adding tactile and visual performance in the neutral scene condition in step 2 did not lead to a significant increase in the predictive power of the equation, see Table C.6 below.

Table C. 6 *Hierarchical multiple regression analyses predicting T1 health care utilisation from T1 tactile and visual performance in the neutral scene condition of the modality bias task, controlling for age, gender, medical conditions (CCI), NA (STAI-T), health anxiety (HAI), anxiety (BSI-A), depression (BSI-D).*

T1: Health care utilisation (*n*=104)						
	Model 1		**Model 2**		**Model 3**	
Variable	***β***	***P***	***β***	***P***	***β***	***p***
Constant		.720		.202		.769
Age	.23	.013*	.21	.022*	.23	.017*
Gender	.26	.005*	.24	.009*	.26	.005*
CCI	.14	.139	.11	.251	.14	.157
HAI	.23	.028*	.24	.022*	.23	.030*
STAI-T	.09	.481	.08	.512	.09	.484
BSI-A	.19	.138	.19	.132	.19	.142
BSI-D	.02	.905	.00	1.00	.02	.906
Neutral scene						
- Tactile	-	-	.11	.220	-	-
- Visual	-	-	-	-	.00	.997
ΔR^2 (*p*)	.30	(.000)*	.01	(.997)	.00	(.473)

The results of the T1 regression analyses suggest that when controlling for covariates general task performance was not a unique predictor of symptom reporting or health care utilisation. In order to control for general task performance, performance in the neutral scene condition was used as a covariate in subsequent hierarchical analyses.

Table C. 7 *Hierarchical multiple-regression analysis predicting T1 symptom reporting from T1 visual performance in each of the picture conditions, controlling for T1 : age, gender, medical conditions, health anxiety, trait anxiety, anxiety and depression and neutral-scene performance or neutral-body performance (n = 104).*

T1 Symptom reporting									
	Model 1			Model 2			Model 3		
Variable	B	SEB	β	B	SEB	β	B	SEB	β
Constant	0.12	3.60	-	0.64	3.41	-	-4.09	3.70	-
Age	-0.00	0.01	-.02	-0.00	0.01	-.01	-0.00	0.01	-.05
Gender	0.42	0.13	.25*	0.43	0.13	.25*	0.39	0.14	.25*
CCI	0.39	0.14	.24*	0.39	0.13	.23*	0.40	0.13	.24*
HAI	0.77	0.33	.20*	0.78	0.33	.20*	0.77	0.32	.20*
STAI-T	0.01	0.01	.15	0.01	0.00	.15	0.01	.01	.14
BSI-A	0.04	0.02	.30*	0.04	0.02	.30*	0.04	.02	.29*
BSI-D	0.02	0.02	.13	0.02	0.02	.12	0.02	0.02	0.16
Visual targets									
Neutral-scene	0.00	0.00	.05	0.00	0.00	.07	-0.00	0.00	-.12
Neutral-body	0.19	1.60	.02	-	-	-	-	-	-
Threat-body	-	-	-	-0.04	1.46	-.01	-	-	-
Threat-scene	-	-	-	-	-	-	2.07	1.64	.22
ΔR^2 (p)	.000 (.91)			.000 (.98)			.01(.21)		

Table C.7 above displays the results of three separate hierarchical regressions predicting symptom reporting. In models 1-3 covariates (age, gender, medical conditions, health anxiety, trait anxiety, anxiety, depression and neutral-scene visual performance) were entered in the first step of the regression. In the second step the addition of visual performance in each picture condition did not lead to a significant increase in the

predictive power of the regression equation. In model 4 neutral-body visual performance was entered as a covariate instead of neutral-scene performance and the addition of threat-body visual performance did not lead to a significant increase in the regression equation. Gender, medical conditions, health anxiety and anxiety were unique predictors of symptom reporting in each of the three models.

Table C. 8 *Hierarchical multiple-regression analysis predicting symptom reporting from tactile performance in each of the picture conditions, controlling for: age, gender, medical conditions, health anxiety, trait anxiety, anxiety and depression and neutral-scene performance or neutral-body performance (n = 104).*

T1 Symptom reporting									
	Model 1			Model 2			Model 3		
Variable	B	SEB	β	B	SEB	β	B	SEB	β
Constant	-0.56	1.85	-	-0.41	1.93	-	-0.79	1.82	-
Age	0.00	0.01	-.00	-0.00	0.01	-.01	-0.00	0.01	-.03
Gender	0.44	0.13	.25*	0.43	0.13	.25*	0.42	0.13	.25*
CCI	0.40	0.13	.24*	0.39	0.14	.24*	0.36	0.13	.22*
HAI	0.74	0.32	.19*	0.76	0.33	.20*	0.75	0.32	.20*
STAI-T	0.01	0.01	.16	0.01	0.01	.15	0.01	0.01	.15
BSI-A	0.04	0.02	.29*	0.04	0.02	.30*	0.04	0.02	.29*
BSI-D	0.02	0.02	.13	0.02	0.02	.13	0.02	0.02	.12
Tactile targets									
Neutral-scene	-1.30	1.69	-.15	-0.22	1.42	-.03	-2.46	1.7	-.28
Neutral-body	1.82	1.72	.21	-	-	-	-	-	-
Threat-body	-	-	-	0.67	1.52	.08	-	-	-
Threat-scene	-	-	-	-	-	-	3.10	1.74	.36.
ΔR^2 (*p*)	.01 (.29)			.00 (.66)			.02 (.08)		

Table C.8 above displays the results of three separate hierarchical regressions predicting symptom reporting. In models 1-3 covariates (age, gender, medical conditions, health anxiety, trait anxiety, anxiety, depression and neutral-scene tactile performance) were entered in the first step of the regression. In the second step the addition of tactile performance in each picture condition did not lead to a significant increase in the predictive power of the regression equation. However, including tactile performance in the threat-scene condition (Model 3) led to a near significant increase in the predictive power of the regression equation. Gender, medical conditions, health anxiety and anxiety were unique predictors of symptom reporting in each of the three models.

Table C. 9 *Hierarchical multiple regression analyses predicting T1: health anxiety (HAI) from T1 age, sex, medical comorbidity (CCI), symptom reporting (PHQ-15), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and visual performance on the MBT.*

T1 Health anxiety									
	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	-0.07	1.11	-	.97	1.05	-	0.98	1.15	-
Age	-0.00	0.00	-.03	-0.01	0.00	-.00	-0.01	.02	-.00
Gender	-0.04	0.04	-.09	-0.04	0.04	-.08	-0.04	.04	-.08
CCI	0.05	0.04	.11	0.04	0.04	.10	-0.04	.04	.10
PHQ-15	0.07	0.03	.28*	0.07	0.03	.28*	.07	.03	.29*
STAI-T	0.01	0.00	.26*	0.01	0.00	.25*	.01	.00	.26*
BSI-A	0.00	0.01	.06	0.00	0.01	.10	.00	.01	.10
BSI-D	0.00	0.01	.04	0.00	0.01	.02	.00	.01	.01
Visual targets									
Neutral-scene	-0.00	0.00	-.26	0.00	0.00	-.09	0.00	0.00	-.09
Neutral-body	0.40	0.49	.17	-	-	-	-	-	-
Threat-body	-	-	-	-0.06	0.45	-.02	-	-	-
Threat-scene	-	-	-	-	-	-	-0.07	0.51	-.03
ΔR^2 (*p*)	.01 (.42)			.00 (.90)			.00 (.90)		

Table C.9 above displays the results of three separate hierarchical regressions predicting health anxiety. In models 1-3 covariates (age, gender, medical conditions, symptom reporting, trait anxiety, anxiety, depression and neutral-scene visual performance) were entered in the first step of the regression. In the second step the addition of visual performance in each picture condition did not lead to a significant increase in the

predictive power of the regression equation. Symptom reporting and trait anxiety were significant unique predictors of heath anxiety in each of the three models.

Table C. 10 Hierarchical multiple regression analyses predicting T1: health anxiety from medical conditions (CCI), symptom reporting, trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D), tactile performance on the MBT.

T1 Health anxiety									
	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	1.17	0.56	-	1.26	0.58	-	1.22	0.56	-
Age	0.00	0.00	-.02	0.00	0.00	-.02	0.00	0.00	-.02
Gender	-0.04	0.04	-.08	-0.04	0.04	-.08	-0.04	0.04	-.08
CCI	0.04	0.04	.09	0.04	0.04	.10	0.04	0.04	.09
PHQ-15	0.07	0.03	.28*	0.07	0.03	.28*	0.07	0.03	.28*
STAI-T	0.01	0.00	.26*	0.01	0.00	.26*	0.01	0.00	.26*
BSI-A	0.00	0.01	.11	0.00	0.01	.11	0.00	0.01	.11
BSI-D	0.00	0.01	.00	0.00	0.01	.01	0.00	0.01	.00
Tactile targets									
Neutral-scene	-0.29	0.53	-.13	-0.06	0.44	-.03	-0.09	0.54	-.04
Neutral-body	0.11	0.54	.05	-	-	-	-	-	-
Threat-body	-	-	-	-0.14	0.47	-.06	-	-	-
Threat-scene	-	-	-	-	-	-	-0.10	0.55	-.05
ΔR^2 (*p*)	.00 (.83)			.00 (.76)			.00 (.86)		

Table C.10 above displays the results of three separate hierarchical regressions predicting health anxiety. In models 1-3 covariates (age, gender, medical conditions, symptom reporting, trait anxiety, anxiety, depression and neutral-scene tactile performance) were entered in the first step of the regression. In the second step the addition of tactile performance in each picture condition did not lead to a significant increase in the

predictive power of the regression equation. Symptom reporting and trait anxiety were unique predictors of health anxiety in each of the three models.

Table C.11 below displays the results of three separate hierarchical regressions predicting health care utilisation. In models 1-3 covariates (age, gender, medical conditions, symptom reporting, trait anxiety, anxiety, depression and neutral-scene visual performance) were entered in the first step of the regression. In model 1 and 3 the addition of visual performance in the neutral-body and threat-scene condition did not lead to a significant increase in the predictive power of the regression equation. In model 2, however, the addition of threat-body visual performance led to a significant increase in the predictive power of the regression equation. Furthermore the addition of threat-body performance increased the predictive power of neutral-scene performance, such that both variables were unique predictors. However, the relationship between neutral-scene performance and health care utilisation was negative and the relationship between threat-body performance and health care utilisation was positive. This suggests that poorer visual performance following threatening body-relevant stimuli and better visual performance following neutral body-irrelevant stimuli are associated with increased health care utilisation. Symptom reporting and trait anxiety were significant unique predictors of heath anxiety in each of the three models.

Table C. 11 Hierarchical multiple regression analyses predicting T1: health care utilisation from T1: medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and visual performance on the MBT.

T1 Health care utilisation									
	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	-3.22	1.95	-	-4.90	1.81	-	-2.76	2.03	-
Age	0.01	0.00	.19	0.01	0.00	.18	0.01	0.00	.19
Gender	0.19	0.07	.25*	0.19	0.07	.24*	0.19	0.07	.24*
CCI	0.12	0.07	.16	0.11	0.07	.14	0.11	0.07	.15
HAI	0.37	0.18	.21*	0.40	0.17	.23*	0.39	0.18	.22*
STAI-T	0.00	0.00	.09	0.01	0.00	.14	0.00	0.00	.07
BSI-A	0.01	0.01	.12	0.01	0.01	.13	0.01	0.01	.17
BSI-D	0.00	0.01	.06	0.00	0.01	.04	0.00	0.01	.06
Visual targets									
Neutral-scene	-0.00	0.00	-.29	-0.00	0.00	-.42*	-0.00	0.00	-.23
Neutral-body	1.40	0.87	.34	-	-	-	-	-	-
Threat-body	-	-	-	2.08	0.77	.49*	-	-	-
Threat-scene	-	-	-	-	-	-	1.19	0.90	.27
ΔR^2 (*p*)	.02 (.11)			.05 (.01)			.01 (.19)		

Table C.12 below displays the results of three separate hierarchical regressions predicting health care utilisation. In models 1-3 covariates (age, gender, medical conditions, symptom reporting, trait anxiety, anxiety, depression and neutral-scene tactile performance) were entered in the first step of the regression. In model 1 and 3 the addition of tactile performance in the neutral-body and threat-scene condition did not lead to a significant increase in the predictive power of the regression equation. In model 2,

however, the addition of threat-body tactile performance led to a significant increase in the predictive power of the regression equation. Furthermore the addition of threat-body performance increased the predictive power of neutral-scene performance, such that neutral-scene performance became a near significant predictor. A statistical effect such as this is known as a suppressor effect (see Chapter4 for a full discussion). For neutral-scene performance the beta coefficient was negative. This suggests that better visual performance in the neutral-scene condition was associated with health care utilisation. For threat-body performance the beta coefficient was positive. This suggests that poorer visual performance in the threat-body condition was associated with health care utilisation.

Table C. 12 Hierarchical multiple regression analyses predicting T1: health care utilisation from T1: medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and tactile performance on the MBT.

	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	-1.45	1.01	-	-2.11	1.02	-	-1.61	.99	-
Age	0.01	0.00	.21*	0.01	0.00	.16	0.01	0.00	.18*
Gender	0.19	0.07	.25*	0.18	0.07	.23*	0.19	0.07	.24*
CCI	0.08	0.07	.11	0.05	0.07	.07	0.06	0.07	.08
HAI	0.40	0.18	.23*	0.42	0.17	.24*	0.40	0.17	.23*
STAI-T	0.00	0.00	.09	0.00	0.00	.10	0.00	0.00	.08
BSI-A	0.01	0.01	.18	0.01	0.01	.19	0.01	0.01	.18
BSI-D	-0.01	0.01	-.00	-0.00	0.01	-.02	-0.00	0.01	-.01
Tactile targets									
Neutral-scene	-0.24	0.92	-.06	-1.12	0.75	-.28*	-1.01	0.93	-.25
Neutral-body	0.75	0.94	.19	-	-	-	-	-	-
Threat-body	-	-	-	1.90	0.80	.47*	-	-	-
Threat-scene	-	-	-	-	-	-	1.61	0.95	.41*
ΔR^2 (*p*)	.01 (.42)			.04 (.02)			.02 (.09)		

C.4. T2 hierarchical regression analyses

Table C.13 below displays the results of four separate hierarchical regressions, each taking PHQ-15 as the target variable and visual and tactile performance in the neutral-scene picture condition as predictors in step 2, and with covariates (age, gender, HAI, STAI-T, STAI-S, PHQ-9) in step 1. The inclusion of visual and tactile performance did not lead to a significant increase in the predictive power of the regression equation.

Table C. 13 Hierarchical multiple regression analyses predicting T2 symptom reporting from T2 tactile and visual performance in the neutral scene condition of the modality bias task, controlling for age, gender, medical conditions (CCI), NA (STAI-T), health anxiety (HAI), anxiety (BSI-A), depression (BSI-D).

T2: Symptom reporting (*n* = 68)						
	Model 1		Model 2		Model 3	
Variable	*β*	*p*	*β*	*p*	*β*	*p*
Constant		.021		.347		.096
Age	-.188	.048*	-.177	.072	-.154	.114
Gender	.042	.655	.054	.587	.086	.393
CCI	.112	.248	.122	.224	.137	.166
HAI	.283	.034*	.279	.038*	.263	.049*
STAI-T	.258	.044*	.266	.041*	.283	.029*
BSI-A	.208	.188	.218	.176	.234	.142
BSI-D	.062	.721	.062	.722	.064	.711
Neutral scene						
- Tactile	-	-	-.045	.657	-	-
- Visual	-	-	-	-	-.126	.214
ΔR^2 (*p*)	.736	(.000)	.002	(.657)	.012	(.214)

The analysis conducted above was repeated with health care utilisation as the dependent variable. Gender and health anxiety were unique predictors of health care utilisation. Adding tactile and visual performance in the neutral scene condition in step 2 did not lead to a significant increase in the predictive power of the equation, see Table C.14 below.

Table C. 14 *Hierarchical multiple regression analyses predicting T2 health care utilisation from T2 tactile and visual performance in the neutral scene condition of the modality bias task, controlling for age, gender, medical conditions (CCI), NA (STAI-T), health anxiety (HAI), anxiety (BSI-A), depression (BSI-D).*

T1: Health care utilisation (*n* = 68)

	Model 1		Model 2		Model 3	
Variable	*β*	*P*	*β*	*P*	*β*	*p*
Constant		.720		.202		.769
Age	.229	.013*	.212	.022*	.229	.017*
Gender	.263	.005*	.244	.009*	.263	.005*
CCI	.137	.139	.109	.251	.137	.157
HAI	.225	.028*	.235	.022*	.225	.030*
STAI-T	.085	.481	.079	.512	.085	.484
BSI-A	.186	.138	.188	.132	.186	.142
BSI-D	.017	.905	.000	1.00	.017	.906
Neutral scene						
- Tactile	-	-	.113	.220	-	-
- Visual	-	-	-	-	.000	.997
ΔR^2 (*p*)	.296	(.000)*	.011	(.997)	.004	(.473)

The results of the regression analyses suggest that when controlling for covariates general task performance was not a unique predictor of symptom reporting or health care utilisation. In order to control for general task performance, performance in the neutral scene condition was used as a covariate in subsequent hierarchical analyses.

Table C. 15 *Hierarchical multiple regression analyses predicting T2: symptom reporting (PHQ-15) from T2: age, sex, medical comorbidity (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and visual performance on the MBT.*

T2 Symptom reporting									
	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	4.68	2.69	-	4.77	2.68	-	4.90	2.84	-
Age	-0.01	0.01	-.15	-0.01	0.01	-.13	-0.01	0.01	-.14
Gender	0.17	0.18	.09	0.16	0.18	.09	0.16	0.18	.09
CCI	0.22	0.16	.12	0.21	0.16	.12	0.21	0.16	.12
HAI	0.24	0.11	.27*	0.25	0.11	.29*	0.24	0.11	.27*
STAI-T	0.02	0.01	.26*	0.02	0.01	.25*	0.02	0.01	.25*
BSI-A	0.04	0.03	.25*	0.04	0.03	.24	0.04	0.03	.26*
BSI-D	0.01	0.02	.08	0.01	0.02	.07	0.01	0.02	.08
Visual targets									
Neutral-scene	-1.43	2.52	-.13	.15	2.50	.01	-0.79	2.52	-.07
Neutral-body	0.09	2.22	.01	-	-	-	-	-	-
Threat-body	-	-	-	-1.54	2.37	-.15	-	-	-
Threat-scene	-	-	-	-	-	-	-0.63	2.64	-.06
ΔR^2 (*p*)	.00 (.97)			.00 (.52)			.00 (.81)		

Table C.15 above displays the results of three separate hierarchical regressions predicting symptom reporting. In models 1-3 covariates (age, gender, medical conditions, health anxiety, trait anxiety, anxiety, depression and neutral-scene visual performance) were entered in the first step of the regression. In the second step the addition of visual performance in each picture condition did not lead to a significant increase in the

predictive power of the regression equation. Health anxiety and trait anxiety were unique predictors of symptom reporting in each of the three models.

Table C. 16 Hierarchical multiple regression analyses predicting T2: symptom reporting from T2: medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D), tactile performance on the MBT.

	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	2.50	2.47	-	2.24	2.47	-	2.58	2.45	-
Age	-0.01	.01	-.17	-0.02	0.01	-.18	-.01	.01	-.17
Gender	0.10	0.18	.05	0.10	0.18	.05	0.11	0.18	.06
CCI	0.21	0.16	.12	0.21	0.16	.12	0.20	0.16	.12
HAI	0.25	0.11	.28*	0.26	0.11	.29*	0.25	0.11	.29*
STAI-T	0.02	0.01	.25*	0.02	0.01	.25*	0.02	0.01	.25*
BSI-A	0.04	0.03	.23	0.04	0.03	.22	0.04	0.03	.23
BSI-D	0.01	0.02	.08	0.01	0.02	.09	0.01	0.02	.07
Tactile targets									
Neutral-scene	-1.34	2.98	-.14	-2.24	2.23	-.23	-1.01	2.88	-.10
Neutral-body	0.86	3.01	.09	-	-	-	-	-	-
Threat-body	-	-	-	1.85	2.19	.19	-	-	-
Threat-scene	-	-	-	-	-	-	0.49	2.79	.05
ΔR^2 (*p*)	.00 (.78)			.01 (.40)			.00 (.86)		

Table C.16 above displays the results of three separate hierarchical regressions predicting symptom reporting. In models 1-3 covariates (age, gender, medical conditions, health anxiety, trait anxiety, anxiety, depression and neutral-scene tactile performance) were entered in the first step of the regression. In the second step the addition of tactile performance in each picture condition did not lead to a significant increase in the

predictive power of the regression equation. Health anxiety and trait anxiety were unique predictors of symptom reporting in each of the three models.

Predicting health anxiety

Table C. 17 Hierarchical multiple regression analyses predicting T2: health anxiety (HAI) from T2: age, sex, medical comorbidity (CCI), symptom reporting (PHQ-15), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and visual performance on the MBT.

	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	2.56	3.02	-	1.84	3.05	-	2.56	3.25	_
Age	-0.01	0.01	-.06	-0.01	0.01	-.07	-0.00	.01	-.03
Gender	0.02	0.20	.01	-0.04	0.20	-.02	-0.05	.21	-.03
CCI	0.12	0.18	.06	0.10	0.18	.05	0.10	.18	.05
PHQ-15	0.29	0.14	.26*	0.31	0.14	.28*	0.31	.14	.27*
STAI-T	0.01	0.01	.18	0.01	0.01	.17	0.01	.01	.16
BSI-A	0.03	0.03	.18	0.03	0.03	.18	0.04	.03	.20
BSI-D	0.04	0.03	.24	0.04	0.03	.23	0.04	.03	.24
Visual targets									
Neutral-scene	-3.99	2.73	-.33	-3.24	2.75	-.27	0.81	2.83	.07
Neutral-body	3.82	2.39	.35	-	-	-	-	-	-
Threat-body	-	-	-	3.35	2.60	.30	-	-	-
Threat-scene	-	-	-	-	-	-	-0.98	2.97	-.08
ΔR^2 (*p*)	.02 (.12)			.01 (.20)			.00 (.74)		

Table C.17 above displays the results of three separate hierarchical regressions predicting health anxiety. In models 1-3 covariates (age, gender, medical conditions, symptom reporting, trait anxiety, anxiety, depression and neutral-scene visual performance) were entered in the first step of the regression. In the second step the addition

of visual performance in each picture condition did not lead to a significant increase in the predictive power of the regression equation. Symptom reporting was a significant unique predictor of heath anxiety in each of the three models.

Table C. 18 Hierarchical multiple regression analyses predicting T2: health anxiety from T2: medical conditions (CCI), symptom reporting, trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D), tactile performance on the MBT.

T2 Health anxiety									
	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	1.76	2.76	-	2.11	2.75	-	1.95	2.72	-
Age	-0.00	0.01	-.04	-0.00	0.01	-.02	-0.00	0.01	-.04
Gender	-0.06	0.20	-.03	-0.04	0.20	-.02	-0.05	0.20	-.02
CCI	0.10	0.18	.05	0.09	0.18	.04	0.11	0.18	.06
PHQ-15	0.31	0.14	.27*	0.32	0.14	.28*	0.31	0.14	.27*
STAI-T	0.01	0.01	.16	0.01	0.01	.16	0.01	0.01	.16
BSI-A	0.03	0.03	.18	0.04	0.03	.20	0.03	0.03	.18
BSI-D	0.04	0.03	.23	0.04	0.03	.22	0.04	0.03	.25
Tactile targets									
Neutral-scene	-.25	3.31	-.02	1.63	2.49	.15	2.16	3.18	.20
Neutral-body	.39	3.34	.04	-	-	-	-	-	-
Threat-body	-	-	-	-1.64	2.44	-.15	-	-	-
Threat-scene	-	-	-	-	-	-	-2.09	3.10	-.20
ΔR^2 (*p*)	.00 (.91)			.00 (.51)			.00 (.50)		

Table C.18 above displays the results of three separate hierarchical regressions predicting health anxiety. In models 1-3 covariates (age, gender, medical conditions, symptom reporting, trait anxiety, anxiety, depression and neutral-scene tactile performance) were entered in the first step of the regression. In the second step the addition

of tactile performance in each picture condition did not lead to a significant increase in the predictive power of the regression equation. Symptom reporting was a unique predictor of health anxiety in each of the models.

Predicting health care utilisation

Table C.19 below displays the results of three separate hierarchical regressions predicting health care utilisation. In models 1-3 covariates (age, gender, medical conditions, symptom reporting, trait anxiety, anxiety, depression and neutral-scene visual performance) were entered in the first step of the regression. In the second step the addition of visual performance in each picture condition did not lead to a significant increase in the predictive power of the regression equation. Health anxiety was a significant unique predictor of heath care utilisation in each of the four models.

Table C. 19 Hierarchical multiple regression analyses predicting T2: health care utilisation from T2: medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and visual performance on the MBT.

T2 Health care utilisation									
	Model 1			Model 2			Model 3		
Variable	B	SEB	β	B	SEB	β	B	SEB	β
Constant	0.05	1.78	-	-0.05	1.77	-	0.22	1.88	-
Age	0.01	0.01	.26*	0.01	0.01	.23	0.01	0.01	.27*
Gender	0.19	0.12	.21	0.19	0.12	.21	0.18	0.12	.20
CCI	-0.04	0.10	-.05	-0.04	0.10	-.05	-0.04	0.10	-.05
PHQ-15	0.12	0.08	.23	0.12	0.08	.24	0.11	0.08	.23
HAI	0.15	0.08	.34*	0.14	0.08	.32	0.15	0.07	.34*
STAI-T	-0.00	0.01	-.11	-0.00	0.01	-.11	-0.00	0.01	-.12
BSI-A	-0.00	0.02	-.03	-0.00	0.02	-.03	-0.00	0.02	.02
BSI-D	0.01	0.02	.08	0.01	0.02	.09	0.01	0.02	.09
Visual targets									
Neutral-scene	-0.12	1.63	-.02	-1.24	1.61	-.23	0.26	1.63	.05
Neutral-body	-0.01	1.43	-.00	-	-	-	-	-	-
Threat-body	-	-	-	1.16	1.53	.23	-	-	-
Threat-scene	-	-	-	-	-	-	-.45	1.71	-.08
ΔR^2 (p)	.00 (.99)			.01 (.45)			.00 (.79)		

Table C.20 below displays the results of three separate hierarchical regressions predicting health care utilisation. In models 1-3 covariates (age, gender, medical conditions, symptom reporting, trait anxiety, anxiety, depression and neutral-scene tactile performance) were entered in the first step of the regression. In the second step the addition

of tactile performance in each picture condition did not lead to a significant increase in the predictive power of the regression equation.

Table C. 20 Hierarchical multiple regression analyses predicting T2: health care utilisation from T2: medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and tactile performance on the MBT.

T2 Health care utilisation									
	Model 1			Model 2			Model 3		
Variable	B	SEB	β	B	SEB	β	B	SEB	β
Constant	-0.37	1.59	-	-0.95	1.55	-	-0.65	1.56	-
Age	0.01	0.01	.26*	0.01	0.01	.21	0.01	0.01	.25*
Gender	0.19	0.12	.21	0.16	0.11	.18	0.17	0.11	.19
CCI	-0.05	0.11	-.06	-0.03	0.10	-.04	-0.06	0.10	-.07
PHQ-15	0.12	0.08	.24	0.10	0.08	.21	0.12	0.08	.23
HAI	0.15	0.07	.34*	0.16	0.07	.36*	0.16	0.07	.36*
STAI-T	-0.00	0.01	-.12	-0.00	0.01	-.10	-0.00	0.01	-.11
BSI-A	-0.00	0.02	-.03	-0.01	0.02	-.08	-0.00	0.02	-.02
BSI-D	0.01	0.02	.08	0.01	0.02	.12	0.00	0.02	.04
Tactile targets									
Neutral-scene	0.88	1.90	.18	-2.14	1.41	-.44	-2.02	1.82	-.42
Neutral- body	-.84	1.92	-.18	-	-	-	-	-	-
Threat-body	-	-	-	2.41	1.38	.51	-	-	-
Threat-scene	-	-	-	-	-	-	2.17	1.76	.47
ΔR^2 (p)	.00 (.66)			.04 (.09)			.02 (.22)		

C.5. Longitudinal hierarchical analyses

Predicting symptom reporting

Table C. 21 Hierarchical multiple regression analyses predicting T2: symptom reporting (PHQ-15) from T1: age, sex, symptom reporting, medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and visual performance on the MBT.

	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	0.15	4.74	-	-3.51	4.60	-	-2.10	5.08	-
Age	-0.01	0.01	-.16	-0.01	0.01	-.17	-0.01	0.01	-.17
Gender	-0.24	0.17	-.14	-0.26	0.17	-.15	-0.26	0.17	-.14
PHQ-15	0.72	0.14	.65**	0.73	0.14	.65**	0.72	0.14	.64**
CCI	-0.12	0.18	-.07	-0.12	0.18	-.07	-0.12	0.18	-.07
HAI	0.30	0.45	.08	0.27	0.44	.07	0.29	0.44	.07
STAI-T	0.01	0.01	.10	0.01	0.01	.12	0.01	0.01	.10
BSI-A	0.00	0.02	.02	0.00	0.02	-.00	0.00	0.02	.02
BSI-D	-0.00	0.02	-.01	0.00	0.02	.02	0.00	0.02	.00
Visual targets									
Neutral-scene	-0.00	0.00	-.10	-0.00	0.00	-.25	-0.00	0.00	-.18
Neutral-body	0.37	2.06	.04	-	-	-	-	-	-
Threat-body	-	-	-	1.98	2.00	.21	-	-	-
Threat-scene	-	-	-	-	-	-	1.37	2.22	.14
ΔR^2 (*p*)	.00 (.86)			.01 (.33)			.00 (.54)		

Table C.21 above displays the results of three separate hierarchical regressions predicting T2 symptom reporting. In models 1-3 T1 covariates (age, gender, symptom

reporting, medical conditions, health anxiety, trait anxiety, anxiety, depression and neutral-scene visual performance) were entered in the first step of the regression. In the second step the addition of visual performance in each picture condition did not lead to a significant increase in the predictive power of the regression equation.

Table C. 22 Hierarchical multiple regression analyses predicting T2: symptom reporting from T1: age, gender, symptom reporting, medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D), tactile performance on the MBT.

T2 Symptom reporting									
	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	-1.13	2.25	-	-2.28	2.25	-	-0.90	2.23	-
Age	-0.02	0.01	-.18	-0.02	0.01	-.22	-0.02	0.01	-.18
Gender	-0.29	0.17	-.16	-0.28	0.17	-.16	-0.29	0.17	-.17
PHQ-15	0.70	0.14	.63**	0.71	0.13	.64**	0.70	0.14	.63**
CCI	-0.18	0.18	-.10	-0.19	0.18	-.11	-0.19	0.18	-.10
HAI	0.38	0.44	.10	0.39	0.43	.10	0.37	0.44	.09
STAI-T	0.01	0.01	.08	0.01	0.01	.09	0.01	0.01	.08
BSI-A	0.01	0.02	.06	0.01	0.02	.07	0.01	0.02	.05
BSI-D	-0.01	0.02	-.06	-0.01	0.02	-.07	-0.01	0.02	-.05
Tactile targets									
Neutral-scene	1.08	2.41	.13	-1.43	1.72	-.17	2.10	2.41	.24
Neutral-body	-0.33	2.52	-.04	-	-	-	-	-	-
Threat-body	-	-	-	2.61	1.79	.29	-	-	-
Threat-scene	-	-	-	-	-	-	-1.44	2.49	-.16
ΔR^2 (*p*)	.00 (.10)			.02 (.15)			.00 (.57)		

Table C.22 above displays the results of three separate hierarchical regressions predicting symptom reporting. In models 1-3 covariates (age, gender, medical conditions, health anxiety, trait anxiety, anxiety, depression and neutral-scene tactile performance) were entered in the first step of the regression. In the second step the addition of tactile performance in each picture condition did not lead to a significant increase in the predictive power of the regression equation.

Predicting health anxiety

Table C. 23 Hierarchical multiple regression analyses predicting T2: health anxiety (HAI) from T1: age, sex, medical conditions (CCI), health anxiety, symptom reporting (PHQ-15), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and visual performance on the MBT.

T2 Health anxiety									
	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	1.64	4.15	-	0.69	4.06	-	-0.52	4.47	-
Age	-0.00	0.01	-.04	-0.00	0.01	-.04	-0.00	0.01	-.04
Gender	0.01	0.15	.00	-0.01	0.15	.01	0.01	0.15	.00
CCI	-0.13	0.16	-.06	-0.13	0.16	-.06	-0.12	0.16	-.06
PHQ-15	0.04	0.12	.03	0.04	0.12	.03	0.05	0.12	.04
HAI	3.49	0.39	.77**	3.48	0.39	.77**	3.47	0.39	.76**
STAI-T	0.01	0.01	.15	0.01	0.01	.15	0.01	0.01	.15
BSI-A	-0.00	0.02	-.02	-0.01	0.02	-.03	-0.01	0.02	-.03
BSI-D	0.01	0.02	.04	0.01	0.02	.04	0.01	0.02	.05
Visual targets									
Neutral-scene	0.00	0.00	.13	0.00	0.00	.00	0.00	0.00	.05
Neutral-body	-1.13	1.80	-.10	-	-	-	-	-	-

Threat-body	-	-	-	-0.71	1.76	-.07	-	-	-
Threat-scene	-	-	-	-	-	-	-0.18	1.95	-.02
ΔR^2 (*p*)	.00 (.55)			.00 (.69)			.00 (.93)		

Table C.23 above displays the results of three separate hierarchical regressions predicting health anxiety. In models 1-3 covariates (age, gender, medical conditions, symptom reporting, trait anxiety, anxiety, depression and neutral-scene visual performance) were entered in the first step of the regression. In the second step the addition of visual performance in each picture condition did not lead to a significant increase in the predictive power of the regression equation.

Table C. 24 Hierarchical multiple regression analyses predicting T2: health anxiety from T1: age, gender, medical conditions (CCI), health anxiety, symptom reporting, trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D), tactile performance on the MBT.

T2 Health Anxiety									
	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	-2.37	1.97	-	-3.24	1.99	-	-2.94	1.95	-
Age	-0.00	0.01	-.04	-0.01	0.01	-.06	-0.01	0.01	-.06
Gender	-0.01	0.15	-.01	-0.00	0.15	-.00	0.00	0.15	.00
CCI	-0.14	0.16	-.07	-0.15	0.16	-.07	-0.14	0.16	-.07
PHQ-15	0.04	0.12	.03	0.05	0.12	.04	0.04	0.12	.03
HAI	3.48	.39	.77**	3.48	0.38	.77**	3.48	.38	.77**
STAI-T	0.01	0.01	.15	0.01	0.01	.15	0.01	0.01	.15
BSI-A	-0.01	0.02	-.04	-0.01	0.02	-.03	-0.01	0.02	-.03
BSI-D	0.01	0.02	.05	0.01	0.02	.04	0.01	0.02	.03
Tactile targets									
Neutral-scene	1.41	2.11	.14	-0.72	1.52	-.07	-.87	2.10	-.09

Neutral-body	-0.79	2.21	-.08	-	-	-	-	-	-
Threat-body	-	-	-	1.67	1.58	.16	-	-	-
Threat-scene	-	-	-	-	-	-	1.72	2.18	.17
ΔR^2 (p)	.00 (.72)			.01 (.30)			.00 (.43)		

Table C.24 above displays the results of three separate hierarchical regressions predicting T2 health anxiety. In models 1-3 T1 covariates (age, gender, medical conditions, health anxiety, symptom reporting, trait anxiety, anxiety, depression and neutral-scene tactile performance) were entered in the first step of the regression. In the second step the addition of tactile performance in each picture condition did not lead to a significant increase in the predictive power of the regression equation.

Predicting health care utilisation

Table C.25 below displays the results of three separate hierarchical regressions predicting T2 health care utilisation. In models 1-3 T1 covariates (age, gender, medical conditions, health care utilisation, symptom reporting, trait anxiety, anxiety, depression and neutral-scene visual performance) were entered in the first step of the regression. In the second step the addition of T1 visual performance in the neutral-body, threat-body and threat-scene picture conditions did not lead to a significant increase in the predictive power of the regression equation.

Table C. 25 Hierarchical multiple regression analyses predicting T2: health care utilisation from T1: medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and visual performance on the MBT.

T2 Health Care Utilisation									
	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	3.16	2.22	-	-1.09	2.25	-	0.35	2.38	-
Age	-0.00	0.00	-.07	-0.00	0.00	-.08	-0.00	0.00	-.07
Gender	-0.05	0.08	-.06	-0.05	0.08	-.06	-.05	0.08	-.06
CCI	0.04	0.08	.06	0.05	0.08	.05	0.05	0.08	.05
HCU	0.94	0.11	.84**	0.88	0.12	.78**	0.91	0.11	.81**
PHQ-15	-0.09	0.06	-.16	-0.07	0.06	-.12	-0.07	0.06	-.14
HAI	0.09	0.21	.05	0.08	0.21	.04	0.09	0.21	.04
STAI-T	-0.01	0.00	-.27*	-0.01	0.00	-.23	-0.01	0.00	-.25*
BSI-A	-0.01	0.01	-.10	-0.01	0.01	-.16	-0.01	0.01	-.15
BSI-D	0.03	0.01	.43*	.04	0.01	.47*	0.03	0.01	.45*
Visual targets									
Neutral-scene	0.00	.00	-.16	-0.00	0.00	-.15	-0.00	0.00	-.02
Neutral -body	-1.15	0.96	.16	-	-	-	-	-	-
Threat-body	-	-	-	0.71	0.97	.15	-	-	-
Threat-scene	-	-	-	-	-	-	0.08	1.04	.02
ΔR^2 (*p*)	.01 (.24)			.00 (.47)			.00 (.94)		

Table C.26 below displays the results of three separate hierarchical regressions predicting T2 health care utilisation. In models 1-3 T1 covariates (age, gender, medical conditions, health care utilisation, symptom reporting, trait anxiety, anxiety, depression and neutral-scene tactile performance) were entered in the first step of the regression. In

the second step the addition of tactile performance in each picture condition did not lead to a significant increase in the predictive power of the regression equation.

Table C. 26 Hierarchical multiple regression analyses predicting T2: health care utilisation from T1: age, gender, medical conditions (CCI), health care utilisation (HCU), symptom reporting (PHQ-15), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and tactile performance on the MBT.

	Model 1			Model 2			Model 3		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*
Constant	0.45	1.06	-	0.31	1.09	-	0.57	1.05	-
Age	-0.00	0.00	-.07	-0.00	0.00	-.08	-0.00	0.00	-.06
Gender	-0.05	0.08	-.06	-0.05	0.08	-.06	-0.06	0.08	-.07
CCI	0.04	0.08	.05	0.04	0.08	.05	0.04	0.08	.04
HCU	0.91	0.11	.81**	0.91	0.11	.80**	0.93	0.11	.82**
PHQ-15	-0.08	0.06	-.14	-0.08	0.06	-.14	-0.07	0.06	-.14
HAI	0.10	0.21	.05	0.94	0.21	.05	0.08	0.21	.04
STAI-T	-0.01	0.00	-.26*	-0.01	0.00	-.25*	-0.01	0.00	-.26*
BSI-A	-0.01	0.01	-.15	-0.01	0.01	-.14	-0.01	0.01	-.15
BSI-D	0.03	0.01	.45*	0.03	0.01	.44*	0.03	0.01	.46*
Tactile targets									
Neutral-scene	0.58	1.11	.14	0.09	0.81	.02	1.04	1.60	.25
Neutral-body	-0.56	1.16	.03	-	-	-	-	-	-
Threat-body	-	-	-	-0.01	0.85	-.00	-1.07	1.16	-.25
Threat-scene	-	-	-						
ΔR^2 (*p*)	.00 (.63)			.00 (.99)			.01 (.36)		

Predicting T2 MBT performance from T1 health care utilisation

Table C. 27 Hierarchical multiple regression analyses predicting T2: visual MBT performance from T1: health care utilisation, controlling for T1: age, sex, symptom reporting, medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and MBT performance.

T2: Visual MBT performance												
	Neutral-Scene			Neutral-body			Threat-body			Threat-scene		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*B*
Step 1:												
Constant	2.37	0.07	-	0.84	0.28	-	1.23	0.28	-	1.13	0.25	-
Age	0.00	0.00	.12	0.00	0.00	.13	0.00	0.00	.16	0.00	0.00	.18
Gender	0.04	0.02	.24	0.03	0.02	.15	0.04	0.02	.19	0.02	0.02	.12
CCI	0.00	0.02	.02	0.01	0.02	.03	0.01	0.02	.08	0.01	0.02	.05
PHQ-15	-0.01	0.01	-.04	-0.1	0.02	-.08	-0.02	0.02	-.14	-0.01	0.01	-.08
HAI	-0.01	0.05	-.03	0.02	0.05	.04	-0.01	0.05	-.02	-0.01	0.04	-.04
STAI-T	0.00	0.00	.13	0.00	0.00	.08	0.00	0.00	.15	0.00	0.00	.05
BSI-A	-0.00	0.00	-.05	0.00	0.00	-.10	0.00	0.00	.06	0.00	0.00	-.03
BSI-D	0.00	0.00	.09	-0.00	0.00	.20	0.00	0.00	.10	0.00	0.00	.29
Visual Targets												
Neutral-scene	.00	.00	.57**	-	-	-	-	-	-	-	-	-
Neutral-body	-	-	-	0.66	0.10	.65**	-	-	-	-	-	-
Threat-body	-	-	-	-	-	-	.52	.11	.54**	-	-	-
Threat-scene	-	-	-	-	-	-	-	-	-	.57	.10	.60**
Step 2:												
T1 HCU	-.00	.03	-.02	-0.03	0.03	-.12	-.02	.03	-.07	-0.03	0.02	-.13
ΔR^2 (*p*)	.00 (.87)			.01 (.29)			.00 (.58)			.01 (.23)		

Table C.27 above displays the results of four separate hierarchical regressions predicting T2 Visual target performance. In each of the models T1 covariates (age, gender, symptom reporting, medical conditions, health anxiety, trait anxiety, anxiety, depression and visual performance) were entered in the first step of the regression. In the second step

the addition of T1 health care utilisation did not lead to a significant increase in the predictive power of the regression equation.

Table C. 28 Hierarchical multiple regression analyses predicting T2: MBT tactile performance from T1: health care utilisation, controlling for T1: age, sex, symptom reporting, medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and MBT performance.

T2: Tactile performance												
	Neutral-Scene			Neutral-body			Threat-body			Threat-scene		
Variable	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*β*	*B*	*SEB*	*B*
Step 1:												
Constant	0.88	0.12	-	0.80	0.14	-	1.19	.26	-	.72	.19	-
Age	0.00	0.00	.16	0.00	0.00	.13	0.00	0.00	.15	0.00	0.00	.10
Gender	0.02	0.02	.12	0.03	0.02	.18	0.02	0.02	.10	0.02	0.02	.13
CCI	0.01	0.02	.03	-0.01	0.02	-.04	0.00	0.02	.02	0.02	0.02	.09
PHQ-15	-0.01	0.01	-.07	-0.01	0.01	-.04	0.01	0.02	.06	-0.01	0.01	-.05
HAI	0.01	0.04	.02	-0.01	0.04	-.02	-0.05	0.05	-.13	-0.01	0.04	-.00
STAI-T	0.00	0.00	.11	0.00	0.00	.14	0.00	0.00	.09	0.00	0.00	.08
BSI-A	-0.00	0.00	-.11	0.00	0.00	.02	-0.00	0.00	-.06	-0.00	0.00	-.08
BSI-D	0.00	0.00	.20	0.00	0.00	.05	0.00	0.00	.11	0.00	0.00	.18
Visual Targets												
Neutral-scene	0.64	0.07	.73**	-	-	-	-	-	-	-	-	-
Neutral-body	-	-	-	0.68	0.08	.73**	-	-	-	-	-	-
Threat-body	-	-	-	-	-	-	0.54	0.10	.58	-	-	-
Threat-scene	-	-	-	-	-	-	-	-	-	0.71	0.07	.77**
Step 2:												
T1 HCU	-0.02	0.02	-.06	-0.02	0.02	-.07	0.00	0.03	.01	-0.03	0.02	-.11
ΔR^2 (*p*)	.00 (.49)			.00 (.47)			.00 (.95)			.01 (.22)		

Table C.28 above displays the results of four separate hierarchical regressions predicting T2 tactile target performance. In each of the models T1 covariates (age, gender,

symptom reporting, medical conditions, health anxiety, trait anxiety, anxiety, depression and visual performance) were entered in the first step of the regression. In the second step the addition of T1 health care utilisation did not lead to a significant increase in the predictive power of the regression equation.

Appendix D: Supplementary analysis for primary care study- SSDT results

D.1. Data distribution

T1 and T2 data were screened for normality; non-normal data and their transformations are displayed in Table D.1 and D.2 below.

Table D. 1 T1: Non-normally distributed variables and their transformations.

Variables	Shapiro-Walk *W*	*p*	Transformation	Shapiro-Wilk *W*	*p*
Age	.900	.000	Unable to transform	-	-
PHQ-15	.924	.000	Square root	.983	.201
HCU	.704	.000	Log	.993	.843
HAI	.970	.015	Square root	.993	.843
BSI-A	.874	.000	Unable to transform	-	-
BSI-D	.875	.000	Unable to transform	-	-
SSDT variables					
Threshold 1	.959	.001	Unable to transform	-	-
Block1					
Light-absent					
-Hit rate	.954	.001	Unable to transform	-	-
-FA rate	.858	.000	Unable to transform	-	-
Light-present					
-Hit rate	.938	.000	Unable to transform	-	-
-FA rate	.863	.000	Unable to transform	-	-
Block 2					
Light-absent					
-Hit rate	.947	.000	Unable to transform	-	-
-FA rate	.822	.000	Unable to transform	-	-
Light-present					
-Hit rate	.911	.000	Unable to transform	-	-
-FA rate	.870	.000	Unable to transform	-	-
Light-absent FA change	.948	.000	Unable to transform	-	-
Light-present FA change	.894	.000	Unable to transform	-	-

Table D. 2 T2: Non-normally distributed data and their transformations.

Variables	Kolmogorov-Smirnov KS	*p*	Transformation	Kolmogorov-Smirnov KS	*p*
Age	.185	.000	Unable to transform	-	-
PHQ-15	.152	.000	Square root	.098	.097
HCU	.157	.000	Log	.099	.092
HAI	.125	.010	Square root	.079	.200
BSI-A	.178	.000	Unable to transform	-	-
BSI-D	.175	.000	Unable to transform	-	-
SSDT variables					
Block1					
Light-absent					
-FA rate	.188	.000	Unable to transform	-	-
Light-present					
-Hit rate	.126	.009	Unable to transform	-	-
-FA rate	.204	.000	Unable to transform	-	-
Block 2					
Light-absent					
-FA rate	.213	.000	Unable to transform	-	-
Light-present					
-Hit rate	.123	.012	Unable to transform	-	-
-FA rate	.230	.000	Unable to transform	-	-
- *c*	.112	.034	Unable to transform		
Light-absent FA change	.177	.000	Unable to transform	-	-
Light-present FA change	.134	.004	Unable to transform	-	-

D.2. Primary analyses

Spearman's correlations were performed between B1 and B2 SSDT performance variables in light-present and light-absent trials at T1 & T2. At T1 false alarm rate was significantly correlated between B1 and B2 for both light-absent and light-present trials as was hit rate, tactile sensitivity (*d*') and response bias (*c*). B1 light-absent false alarm rate was significantly correlated with B1 light-absent hit rate and B2 light-absent false alarm rate was significantly correlated with B2 light-absent and light-present hit rate. B2 light-absent tactile sensitivity was significantly correlated with B2 light-absent and light-present response bias (see Table D.3 & D.4 below).

At T2 false alarm rate was significantly correlated between B1 and B2 for both light-absent and light-present trials as was hit rate, tactile sensitivity, and response bias. False alarm rate and hit rate were not significantly correlated with one another. Tactile sensitivity and response bias were significantly correlated with one another in B1 light-absent trials and B2 light-absent and light-present trials (see Table D.5 & D.6 below).

Table D. 3 *Zero-order correlations between B1 and B2 false alarms (FAs) and hits, in light-absent (LA) and light-present (LP) trials at T1.*

			T1: **FAs**				**Hits**			
			B1		B2		B1		B2	
			LA	LP	LA	LP	LA	LP	LA	LP
FAs	B1	LA	-	.53**	.63**	.48**	.20*	.13	.13	.13
		LP		-	.50**	.54**	.15	.09	.17	.11
	B2	LA			-	.61**	.18	.11	.26**	.21*
		LP				-	.08	.00	.11	.09
Hits	B1	LA					-	.78**	.67**	.66**
		LP						-	.57**	.70**
	B2	LA							-	.82**
		LP								-

*p <.05. ** p <.001.

Table D. 4 *Correlations between B1 and B2 tactile sensitivity (d') and response bias (c) in light-absent (LA) and light-present (LP) trials at T1.*

			T1: *d'*				***c***			
			B1		B2		B1		B2	
			LA	LP	LA	LP	LA	LP	LA	LP
d'	B1	LA	-	.57**	.59**	.49**	-.14	-.16	-.16	-.16
		LP		-	.41**	.55**	-.08	-.11	.02	-.12
	B2	LA			-	.72**	-.12	-.17	-.36**	-.37**
		LP				-	-.18	-.29**	-.39**	-.41**
c	B1	LA					-	.63**	.61**	.51**
		LP						-	.57**	.54**
	B2	LA							-	.76**
		LP								-

*p <.05. ** p <.001.

Table D. 5 *Zero-order correlations between B1 and B2 false alarms (FAs) and hits, in light-absent (LA) and light-present (LP) trials at T2.*

			T1: FAs				**Hits**			
			B1		B2		B1		B2	
			LA	LP	LA	LP	LA	LP	LA	LP
FAs	B1	LA	-	.52**	.64**	.49**	.05	.01	-.02	-.03
		LP		-	.46**	.49**	.10	.13	.12	.06
	B2	LA			-	.66**	.08	.10	.20	.15
		LP				-	-.07	.04	.11	.10
Hits	B1	LA					-	.79**	.62**	.57**
		LP						-	.58**	.68**
	B2	LA							-	.85**
		LP								-

*p <.05. ** p <.001.

Table D. 6 *Zero-order correlations between B1 and B2 tactile sensitivity (d') and response bias (c) in light-absent (LA) and light-present (LP) trials at T2.*

			T1: *d'*				***c***			
			B1		B2		B1		B2	
			LA	LP	LA	LP	LA	LP	LA	LP
d'	B1	LA	-	.72**	.67**	.63**	-.26*	-.40**	-.22	-.16
		LP		-	.50**	.63**	-.29*	-.21	-.19	-.19
	B2	LA			-	.77**	-.14	-.27*	-.34**	-.31**
		LP				-	-.19	-.15*	-.30*	-.19
c	B1	LA					-	.64**	.54**	.39**
		LP						-	.51**	.57**
	B2	LA							-	.74**
		LP								-

*p <.05. ** p <.001.

Correlations were performed between T1 and T2 false alarm rate and hits in light-present and light-absent trials for blocks 1 and 2. False alarm rate was significantly correlated between T1 and T2 for both light-absent and light-present trials in blocks 1 and 2. Hit rate was correlated between T1 and T2 in both light-absent and light-present trials in

block 1 and for light absent trials only in block 2. Hit rate and false alarm rate were not correlated with one another between T1 and T2. (see Table D.7 & D.8 below)

Table D. 7 *Zero-order correlations between T1 and T2 false alarms (FAs) and hits in light-absent (LA) and light-present (LP) trials for blocks 1 (B1) and 2 (B2).*

			T1: FAs				**Hits**			
			B1		B2		B1		B2	
			LA	LP	LA	LP	LA	LP	LA	LP
T2: FAs	B1	LA	.412**	.318**	.276*	.385**	.119	.143	.122	-.015
		LP		.371**	.363**	.383**	.232	.231	.102	.022
	B2	LA			.242*	.413**	.190	.126	.109	.067
		LP				.522**	.063	-.045	.151	.034
Hits	B1	LA					.345**	.328**	.352**	.217
		LP						.228	.218	.114
	B2	LA							.080	.016
		LP								-.020

*p <.05. ** p <.001.

Table D. 8 *Correlations between T1 and T2 tactile sensitivity (d') and response bias (c) in light-absent (LA) and light-present (LP) trials for blocks 1 (B1) and 2 (B2).*

			T1: *d'*				***c***			
			B1		B2		B1		B2	
			LA	LP	LA	LP	LA	LP	LA	LP
T2: *d'*	B1	LA	.30*	.16	.05	.07	-.21	-.26*	-.13	-.03
		LP		.17	.11	.17	-.23	-.09	-.02	.15
	B2	LA			.07	.04	-.16	-.01	.00	.07
		LP				.08	-.06	.04	.02	.10
c	B1	LA					.40**	.23	.25*	.15
		LP						.41**	.26*	.17
	B2	LA							.28*	.28*
		LP								.26*

*p <.05. ** p <.001.

Table D.9 below displays correlations between T1 and T2 false alarm change (block 2 false alarm rate – block 1 false alarm rate) in light-present and light-absent trials. There was a significant correlation between light-absent and light-present change at T2 but not at T1 and there was no association between T1 and T2 change variables.

Table D. 9 Correlations between light-absent (LA) and light-present (LP) false alarm change at T1 (n=109) and T2 (n=70).

		T1:		**T2:**	
		LA	**LP**	**LA**	**LP**
T1:	**LA**	-	.09	.22	-.03
	LP		-	-.07	.06
T2:	**LA**			-	.29*
	LP				-

*p <.05. ** p <.001.

D.3. T1 Hierarchical regression analyses

Table D.10 below displays the results of six separate hierarchical regressions taking PHQ-15 as the target variable and tactile threshold, block 2 false alarms, change in false alarms in light-absent and present conditions as predictors in step 2, and with covariates (age, gender, CCI, HAI, STAI-T, BSI-A and BSI-D) in step 1. In model 4, when FA change in the light-absent condition was entered as a predictor there was a significant improvement in the regression equation. None of the other predictors led to a significant improvement in the regression equation. Gender, medical conditions, health anxiety and anxiety were unique predictors of symptom reporting in each of the five models.

Table D. 10 Hierarchical multiple regression analyses predicting T1 symptom reporting from T1: false alarm (FA) variables, controlling for age, gender, medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A) and depression (BSI-D). (n = 108).

T1 Symptom reporting															
	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Const.	0.84	0.52	-	0.86	0.43	-	0.96	0.42	-	1.08	.41	-	1.04	0.44	-
Age	-0.00	0.01	-.02	0.00	0.01	.00	-0.00	0.01	-.02	-0.00	.01	-.01	-0.00	0.01	-.03
Gen	0.40	0.13	.23*	0.42	0.13	.24*	0.41	0.13	.23*	0.40	.13	.23*	0.42	0.13	.24*
CCI	0.42	0.13	.25*	0.44	0.13	.26*	0.43	0.13	.25*	0.42	.13	.25*	0.43	0.13	.25*
HAI	0.19	0.08	.20*	0.16	0.08	.17*	0.18	0.08	.20*	0.16	.08	.17*	0.17	0.09	.18*
STAI-T	0.01	0.01	.19	0.01	0.01	.19	0.01	0.01	.19	0.01	0.01	.18	0.01	0.01	.19
BSI-A	0.05	0.02	.32*	0.05	0.02	.30*	0.05	0.02	.33*	0.05	0.02	.32*	0.05	0.02	.33*
BSI-D	0.01	0.02	.03	0.01	0.02	.06	0.01	0.02	.04	0.01	0.02	.06	0.01	0.02	.04
Tac. Thresh.	-0.01	0.00	-0.03	-	-	-	-	-	-	-	-	-	-	-	-
FAs															
B2 LA FAs	-	-	-	0.70	0.53	.10	-	-	-	-	-	-	-	-	-
B2 LP FAs	-	-	-	-	-	-	-0.06	0.56	-.01	-	-	-	-	-	-
LA change	-	-	-	-	-	-	-	-	-	1.55	0.59	.19	-	-	-
LP change	-	-	-	-	-	-	-	-	-	-	-	-	0.32	0.52	.05
ΔR^2 (*P*)	.00 (.69)			.01 (.19)			.00 (.91)			.03 (.01)			.00 (.55)		

*p <.05. ** p <.001.

Table D.11 below displays the results of five separate hierarchical regressions taking HAI as the target variable and tactile threshold, block 2 false alarms and change in false alarms in light-absent and present conditions as predictors in step 2, and with covariates (age, gender, CCI, HAI, STAI-T, BSI-A and BSI-D) in step 1. In model 3 and 5, when block 2 light-present FAs and light-present false alarm change were entered as

predictors there was a significant improvement in the regression equation. None of the other predictors led to a significant improvement in the regression equation. Symptom reporting and trait anxiety were unique predictors of health anxiety in each of the five models.

Table D. 11 Hierarchical multiple regression analyses predicting T1 health anxiety (HAI) from T1: false alarm (FA) variables, controlling for age, gender, medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A) and depression (BSI-D). (n = 108).

T1 Health anxiety															
	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Cons.	2.39	0.58	-	1.80	0.49	-	1.87	0.48	-	2.03	0.49	-	2.24	0.47	-
Age	0.00	0.01	-.00	0.00	0.01	.05	0.00	0.01	.02	0.00	0.01	.02	-0.00	0.01	-.05
Gen	-0.12	0.17	-.06	-0.09	0.17	-.05	-0.14	-0.14	-.07	-0.12	0.17	-.06	-0.05	0.16	-.03
CCI	0.15	.17	.08	0.14	0.17	.07	0.10	0.10	.06	0.12	0.17	.07	0.11	0.16	.06
PHQ-15	0.27	0.12	.25*	0.23	0.12	.22*	0.26	0.26	.24*	0.24	0.12	.22*	0.22	0.11	.21*
STAI-T	0.02	0.01	.26*	0.02	0.01	.28*	0.02	0.02	.27*	0.02	0.01	.27*	0.02	0.01	.26*
BSI-A	0.02	0.02	.12	0.01	0.02	.09	0.02	0.02	.10	0.02	0.02	.12	0.02	0.02	.15
BSI-D	0.01	0.02	.07	0.01	0.02	.09	0.01	0.01	.05	0.01	0.02	.07	0.01	0.02	.07
Tac. Thresh.	0.00	0.00	.10	-	-	-	-	-	-	-	-	-	-	-	-
FAs															
B2 LA	-	-	-	1.04	0.64	.14	-	-	-	-	-	-	-	-	-
B2 LP	-	-	-	-	-	-	1.31	0.65	.16*	-	-	-	-	-	-
LA change	-	-	-	-	-	-	-	-	-	0.57	0.76	.06	-	-	-
LP Change	-	-	-	-	-	-	-	-	-	-	-	-	1.75	0.58	.25*
ΔR^2 (*P*)	.01 (.21)			.02 (.11)			.03 (.05)			.00 (.46)			.05 (.00)		

*p <.05. ** p <.001.

Table D.12 below displays the results of five separate hierarchical regressions taking health care utilisation as the target variable and tactile threshold, block 2 false alarms and change in false alarms in light-absent and present conditions as predictors in

step 2, and with covariates (age, gender, CCI, HAI, STAI-T, BSI-A and BSI-D) in step 1. None of the predictors led to a significant improvement in the regression equation. Age and gender were unique predictors of health care utilisation in each of the five models.

Table D. 12 Hierarchical multiple regression analyses predicting T1 health care utilisation (HCU) from T1: false alarm (FA) variables, controlling for age, gender, medical conditions (CCI), symptom reporting (PHQ-15) health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A) and depression (BSI-D). (n = 108).

T1 Health Care Utilisation															
	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Const.	0.17	0.28	- 0.00	- 0.24	0.24	- 0.02	- 0.23	0.23	- 0.02	0.02	0.02	- 0.07	- 0.24	0.24	- 0.07
Age	0.01	0.00	.20*	0.01	0.00	.19*	0.01	0.00	.21*	0.01	0.01	.22*	0.01	0.00	.22*
Gen.	0.16	0.08	.20*	0.15	0.08	.19*	0.16	0.08	.20*	0.16	0.16	.20*	0.15	0.08	.19*
CCI	0.10	0.08	.13	0.08	0.08	.10	0.09	0.07	.11	0.09	0.09	.14	0.08	0.07	.11
PHQ-15	0.08	0.05	.18	0.09	0.06	.19	0.08	0.05	.17	0.06	0.06	.14	0.08	0.05	.18
HAI	0.06	0.05	.14	0.07	0.05	.17	0.08	0.05	.19	0.00	0.06	.15	0.08	0.05	.18
STAI-T	0.00	0.00	.07	0.00	0.00	.07	0.00	0.00	.07	0.01	0.00	.08	0.00	0.00	.07
BSI-A	0.01	0.01	.16	0.01	0.01	.17	0.01	0.01	.16	- 0.00	0.01	.16	0.01	0.01	.14
BSI-D	- 0.00	0.01	-.05	- 0.00	0.01	-.07	- 0.00	0.01	- 0.06	- 0.00	0.01	-.05	- 0.00	0.01	-.06
Tac. Thresh.	- 0.01	0.00	11	-	-	-	-	-	-	-	-	-	-	-	-
FAs															
B2 LA	-	-	-	- 0.20	0.29	-.06	-	-	-	-	-	-	-	-	-
B2 LP	-	-	-	-	-	-	- 0.38	0.30	-.11	-	-	-	-	-	-
LA Change	-	-	-	-	-	-	-	-	-	0.38	0.34	.10	-	-	-
LP Change	-	-	-	-	-	-	-	-	-	-	-	-	- 0.18	0.28	-.06
ΔR^2 (*P*)	.01 (.23)			.00 (.50)			.01 (.21)			.01 (.26)			.00 (.53)		

*$p < .05$. ** $p < .001$.

D.4. T2 Hierarchical regression analysis

Table D.13 below displays the results of five separate hierarchical regressions taking PHQ-15 as the target variable and tactile threshold, block 2 false alarms and change in false alarms in light-absent and present conditions as predictors in step 2, and with covariates (age, gender, CCI, HAI, STAI-T, BSI-A and BSI-D) in step 1. None of the predictors led to a significant improvement in the regression equation. Age, health anxiety and trait anxiety were unique predictors of symptom reporting.

Table D. 13 Hierarchical multiple regression analyses predicting T2 symptom reporting from T2: tactile threshold and false alarm (FA) variables; controlling for age, gender, medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A) and depression (BSI-D (n = 70).).

T2 Symptom reporting															
	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Con.	1.08	0.74	-	1.26	0.55	-	1.31	0.54	-	1.29	0.54	-	1.28	0.54	-
Age	-0.01	0.01	-0.16	-0.02	0.01	-.18	-0.02	0.01	-.18*	-0.02	0.01	-.18	-0.02	0.01	-.18*
Gend.	0.10	0.17	.05	0.08	0.17	.04	0.09	0.17	.05	0.08	0.17	.05	0.08	0.17	.05
CCI	0.20	0.16	.11	0.19	0.16	.12	0.20	0.16	.12	0.20	0.16	.11	0.20	0.16	.11
HAI	0.24	0.11	.27*	0.25	0.11	.28*	0.25	0.11	.29*	0.25	0.11	.28*	0.26	0.12	.30*
STAI-T	0.02	0.01	.26*	0.02	0.01	.25	0.02	0.01	.24*	0.02	0.01	.24	0.02	0.01	.24
BSI-A	0.04	0.03	24	0.03	0.03	.21	0.04	0.03	.23	0.04	0.03	.22	0.04	0.03	.22
BSI-D	0.01	0.02	.07	0.01	0.02	.07	0.01	0.02	.07	0.01	0.02	.07	0.01	0.03	.07
Tac. Thresh.	-0.01	0.00	-.04	-	-	-	-	-	-	-	-	-	-	-	-
FAs															
B2 LA	-	-	-	0.15	0.61	.02	-	-	-	-	-	-	-	-	-
B2 LP	-	-	-	-	-	-	-0.09	0.44	-.02	-	-	-	-	-	-
LA Change	-	-	-	-	-	-	-	-	-	0.03	0.71	.00	-	-	-
LP change	-	-	-	-	-	-	-	-	-	-	-	-	-0.14	0.51	-.03
ΔR^2 (*P*)	.00 (.67)			.00 (.81)			.00 (.83)			.00 (.97)			.00 (.78)		

*$p < .05$. ** $p < .001$.

Table D.14 below displays the results of five separate hierarchical regressions taking HAI as the target variable and tactile threshold, block 2 false alarms and change in false alarms in light-absent and present conditions as predictors in step 2, and with covariates (age, gender, CCI, HAI, STAI-T, BSI-A and BSI-D) in step 1. In model 5, when light-present false alarm change was entered as a predictor there was a significant improvement in the regression equation. None of the other predictors led to a significant improvement in the regression equation. Symptom reporting was also a unique predictor of health anxiety in each of the five models.

Table D. 14 Hierarchical multiple regression analyses predicting T2 health anxiety (HAI) from T2: tactile threshold and false alarm (FA) variables, controlling for T2: age, gender, medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A) and depression (BSI-D) (n = 70).

T2 Health anxiety															
	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Con.	1.15	0.80	-	2.11	0.58	-	2.00	0.57	-	2.08	0.55	-	1.94	0.54	-
Age	0.00	0.01	.02	-0.00	0.01	-.03	-0.00	0.01	-.02	-0.00	0.01	-.04	0.00	0.01	.00
Gen.	0.01	0.19	.00	-0.04	0.19	-.02	-0.07	0.19	-.03	-0.06	0.18	-.03	-0.02	0.18	-.01
CCI	0.10	0.17	.05	0.10	0.18	.05	0.07	0.19	.03	0.10	0.17	.05	0.06	0.17	.03
PHQ-15	0.28	0.13	.25*	0.31	0.14	.27*	0.31	0.14	.27*	0.29	0.13	.26*	0.29	0.13	.26*
STAI-T	0.02	0.01	.21	0.13	0.01	.16	0.01	0.01	.17	0.02	0.01	.20	0.02	0.01	.20
BSI-A	0.05	0.03	.26	0.04	0.03	.19	0.03	0.03	.17	0.04	0.03	.19	0.03	0.03	.18
BSI-D	0.03	0.03	.20	0.04	0.03	.23	0.04	0.03	.23	0.03	0.03	.19	0.03	0.03	.19
Tac. Thresh	0.00	0.00	-.16	-	-	-	-	-	-	-	-	-	-	-	-
FAs															
B2 LA	-	-	-	-0.06	0.68	-.01	-	-	-	-	-	-	-	-	-
B2 LP							0.43	0.49	.08	-	-	-	-	-	-
LA change	-	-	-	-	-	-	-	-	-	1.26	0.75	.14	-	-	-
LP change	-	-	-	-	-	-	-	-	-	-	-	-	1.32	0.51	.22*
ΔR^2 (*P*)	.02 (.11)			.00 (.94)			.01 (.38)			.02 (.10)			.04 (.01)		

*$p < .05$. ** $p < .001$.

Table D.15 below displays the results of five separate hierarchical regressions taking HCU as the target variable and tactile threshold, block 2 false alarms and change in false alarms in light-absent and present conditions as predictors in step 2, and with covariates (age, gender, CCI, PHQ-15, HAI, STAI-T, BSI-A and BSI-D) in step 1. None of the predictors led to a significant improvement in the regression equation. Age and health anxiety were unique predictors of health care utilisation in the final models.

Table D. 15 Hierarchical multiple regression analyses predicting T1 health care utilisation (HCU) from T1: false alarm (FA) variables, controlling for age, gender, medical conditions (CCI), symptom reporting (PHQ-15) health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A) and depression (BSI-D). (n = 70).

T2 Health care utilisation															
	Model 1			Model 2			Model 3			Model 4			Model 5		
Variable	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Cons.	0.16	0.47	- 0.22	-	0.36	-	- 0.28	0.36	-	- 0.25	0.36	-	- 0.26	0.36	-
Age	0.01	0.01	.19	0.01	0.01	.25*	0.01	0.01	.26*	0.01	0.01	.25*	0.01	0.01	.26*
Gender	0.15	0.11	.17	0.19	0.11	.21	-.17	0.11	.19	0.17	0.11	.19	0.18	0.11	.20
CCI	- 0.05	0.10	-.05	- 0.03	0.10	-.03	- 0.05	0.10	-.05	- 0.04	0.10	-.05	- 0.04	0.10	-.05
PHQ-15	0.12	0.08	.25	0.12	0.08	.24	0.12	0.08	.24	0.12	0.08	.24	0.12	0.08	.24
HAI	0.17	0.07	.39*	0.15	0.07	.34*	0.15	0.07	.34*	0.14	0.08	.31	0.14	0.08	.32
STAI-T	- 0.01	0.01	-.18	- 0.01	0.01	-.14	- 0.00	0.01	-.11	- 0.00	0.01	-.09	- 0.00	0.01	-.10
BSI-A	- 0.01	0.02	-.12	0.00	0.02	-.01	- 0.00	0.02	- 0.04	- 0.00	0.02	-.03	- 0.00	0.02	-.03
BSI-D	0.01	0.02	.11	0.01	0.02	.08	0.01	0.02	0.08	0.00	0.02	.06	0.01	0.02	.08
Tac. Thresh	0.00	0.00	.18	-	-	-	-	-	-	-	-	-	-	-	-
FAs															
B2 LP	-	-	-	- 0.28	0.39	-.09	-	-	-	-	-	-	-	-	-
B2 LP	-	-	-	-	-	-	0.08	0.28	.03	-	-	-	-	-	-
LA Change	-	-	-	-	-	-	-	-	-	0.36	0.45	.09	-	-	-
LP Change	-	-	-	-	-	-	-	-	-	-	-	-	0.15	0.32	0.06
ΔR^2 (*P*)	.02 (.17)			.01 (.47)			.00 (.79)			.01 (.43)			.00 (.66)		

*$p < .05$. ** $p < .001$.

D.5. Longitudinal hierarchical analyses

Table D.16 below displays the results of five separate hierarchical regressions taking PHQ-15 as the target variable and tactile threshold, block 2 false alarms and change in false alarms in light-absent and present conditions as predictors in step 2, and with

covariates (age, gender, CCI, PHQ-15, HAI, STAI-T, BSI-A and BSI-D) in step 1. None of the predictors led to a significant improvement in the regression equation. T1 symptom reporting was a unique predictor of T2 symptom reporting.

Table D. 16 Hierarchical multiple regression analyses predicting T2 symptom reporting from T1: tactile threshold and false alarm (FA) variables; controlling for T1: age, gender, medical conditions (CCI), symptom reporting (PHQ-15), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A) and depression (BSI-D) (n = 71).

T2 Symptom reporting															
	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Step 1:	**T1 covariates**														
Const.	1.04	0.72	-	0.90	0.57	-	0.98	0.56	-	1.06	0.55	-	0.86	0.56	-
Age	-0.01	0.01	-.17	0.01	0.01	-.16	-0.14	0.01	-.17	-0.01	0.01	-.14	-0.01	0.01	-.16
Gender	-0.24	0.17	-.14	-0.22	0.17	-.13	-0.24	0.17	-.14	-0.24	0.17	-.14	-0.28	0.17	-.16
CCI	-0.13	0.19	-.07	-0.13	0.18	-.07	-0.13	0.18	-.07	-0.14	0.18	-.08	-0.10	0.18	-.06
PHQ-15	0.69	0.14	.63**	0.67	0.14	.61**	0.68	0.14	.62**	0.67	0.14	.61**	0.69	0.14	.63**
HAI	0.09	0.11	.09	0.09	0.11	.09	0.10	0.11	.10	0.06	0.11	.06	0.12	0.11	.13
STAI-T	0.01	0.01	.07	0.01	0.01	.08	0.01	0.01	.07	0.01	0.01	.08	0.00	0.01	.05
BSI-A	0.01	0.02	.04	0.00	0.02	.03	0.01	0.02	.04	0.10	0.02	.06	0.01	0.02	.06
BSI-D	-0.00	0.02	-.02	-0.00	0.02	-.01	-0.00	0.20	-.02	-0.00	0.02	-.02	-0.01	0.02	-.04
Step 2:	**T1 SSDT variables**														
Thresh. *FAs*	0.00	0.00	.02	-	-	-	-	-	-	-	-	-	-	-	-
B2 LA	-	-	-	0.41	0.80	.05	-	-	-	-	-	-	-	-	-
B2 LP	-	-	-	-	-	-	-0.30	0.82	-.03	-	-	-	-	-	-
LA change	-	-	-	-	-	-	-	-	-	1.18	0.82	.13	-	-	-
LP change	-	-	-	-	-	-	-	-	-	-	-	-	-0.86	0.82	-.11
ΔR^2 (*P*)	.00 (.86)			.00 (.61)			.00 (.72)			.02 (.15)			.01 (.30)		

*$p < .05$. ** $p < .001$.

Table D.17 below displays the results of five separate hierarchical regressions taking health anxiety as the target variable and tactile threshold, block 2 false alarms and change in false alarms in light-absent and present conditions as predictors in step 2, and with covariates (age, gender, CCI, HAI, PHQ-15, STAI-T, BSI-A and BSI-D) in step 1. None of the predictors led to a significant improvement in the regression equation. T1 health anxiety was a unique predictor of T2 health anxiety in each of the final models.

Table D. 17 Hierarchical multiple regression analyses predicting T2 health anxiety (HAI) from T1: tactile threshold and false alarm (FA) variables, controlling for T1: age, gender, medical conditions (CCI), physical symptom reporting (PHQ-15), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A) and depression (BSI-D) (n = 71).

T2 Health anxiety															
	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Step 1:	**T1 covariates**														
Cons.	0.79	0.63	-	0.11	0.50	-	0.22	0.49	-	0.32	0.49	-	.22	0.49	-
Age	-0.01	0.01	-.09	-0.00	0.01	-.04	-0.01	0.01	-.01	-0.01	0.01	-.06	-0.01	0.01	-.05
Gen.	0.01	0.15	.01	0.06	0.15	.03	0.01	0.15	.01	0.00	0.15	.00	-0.03	0.15	-.02
CCI	-0.02	0.16	-.01	-0.05	0.16	-.03	-0.10	0.16	-.05	-0.07	0.16	-.03	-0.04	0.16	-.02
PHQ-15	0.01	0.12	.01	-0.05	0.12	-.04	-0.10	0.12	-.01	-0.02	0.12	-.01	-0.01	0.12	-.01
HAI	0.84	0.10	.77**	0.85	0.09	.79**	0.85**	0.10	.79**	0.86	0.10	.79**	0.89	0.10	.82**
STAI-T	0.01	0.08	.10	0.01	0.01	.14	0.01	0.01	-.07	0.01	0.01	.11	0.01	0.01	.09
BSI-A	-0.01	0.02	-.05	-0.02	0.02	-.08	-0.01	0.02	.08	-0.01	0.02	-.05	-0.01	0.02	-.04
BSI-D	0.02	0.02	.11	0.02	0.02	.10	0.01	0.02	.08	0.02	0.02	.08	0.01	0.02	.07
Step 2:	**SSDT variables**														
Thresh	0.00	0.00	.09	-	-	-	-	-	-	-	-	-	-	-	-
FAs															
B2 LA	-	-	-	1.06	0.69	.11	-	-	-	-	-	-	-	-	-
B2 LP	-	-	-	-	-	-	0.85	0.72	.08	-	-	-	-	-	-
LA Change	-	-	-	-	-	-	-	-	-	0.27	0.73	0.03	-	-	-
LP Change	-	-	-	-	-	-	-	-	-	-	-	-	-0.80	.73	-.09
ΔR^2 (*P*)	.01 (.23)			.01 (.13)			.01 (.24)			.00 (.72)			.01 (.27)		

*p <.05. ** p <.001.

Table D.18 below displays the results of five separate hierarchical regressions taking health care utilisation as the target variable and tactile threshold, block 2 false

alarms and change in false alarms in light-absent and present conditions as predictors in step 2, and with covariates (age, gender, CCI, HCU, PHQ-15, HAI, STAI-T, BSI-A and BSI-D) in step 1. None of the predictors led to a significant improvement in the regression equations. T1 health care utilisation and depression were both significant positive predictors of T2 health care utilisation. T1 trait anxiety was a significant negative predictor of T2 health care utilisation.

Predicting FAs

Table D.19 below displays the results of four separate hierarchical regressions taking T2 FA variables as the target variables and T1 symptom reporting as the predictor in step 2, with T1 covariates (age, gender, CCI, HAI, STAI-T, BSI-A and BSI-D and T1 FA variables) in step 1.

When symptom reporting was entered in step 2 as a predictor of T2 B2 light-present FAs there was a significant improvement in the regression equation. When symptom reporting was entered in step 2 as a predictor of T2 light-absent FA change there was also a near significant improvement in the regression equation. These results suggest that the tendency to experience FAs may be a consequence rather than a cause of physical symptom reporting.

Table D. 19 Hierarchical multiple regression analyses predicting T2 false alarm (FA) variables; from T1 symptom reporting controlling for T1: age, gender, medical conditions (CCI), health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A) and depression (BSI-D) and FA variables (n = 70).

	B2 LA			B2 LP			LA Change			LP Change		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Step 1:												
Const.	0.11	0.12	-	-.08	0.15	-	-0.04	0.11	-	-0.04	0.15	-
Age	0.00	0.00	-.01	-.00	0.00	-.10	0.00	0.00	.08	-0.00	0.00	-.18
Gender	0.05	0.04	.18	.03	0.04	.08	0.03	0.03	.11	-0.03	0.05	-.08
CCI	0.08	0.04	.27	-.02	0.05	-.06	0.01	0.03	.05	0.01	0.05	.02
HAI	-0.00	0.02	-.01	.01	0.03	.06	0.04	0.02	.33	0.07	0.03	.41*
STAI-T	-0.00	0.00	-11	0.00	0.00	-.03	-0.00	0.00	-.06	-0.00	0.00	-.17
BSI-A	0.00	0.01	.06	-0.00	0.01	-.06	-0.00	0.00	-.15	-0.00	0.01	-.03
BSI-D	0.01	0.01	.21	-0.01	0.01	-.17	0.01	0.00	.29	-0.00	0.01	-.09
T1 FAs												
B2 LA	0.43	0.16	.33**	-	-	-	-	-	-	-	-	-
B2 LP	-	-	-	0.96	0.21	.50**	-	-	-	-	-	-
LA change	-	-	-	-	-	-	0.19	0.15	.16	-	-	-
LP change	-	-	-	-	-	-	-	-	-	0.08	.21	.05
Step 2:												
PHQ-15	-0.01	0.03	-.06	0.07	0.03	.30*	-0.05	0.03	-0.32	0.00	0.04	.01
ΔR^2 (*P*)		.00 (.59)			.05 (.04)			.05 (.07)			.00 (.98)	

*$p < .05$. ** $p < .001$.

Table D.20 below displays the results of four separate hierarchical regressions taking each of the T2 false alarm variables as the target variable and health anxiety as the predictor in step 2, and controlling for T1 covariates (age, gender, CCI, PHQ-15, STAI-T, BSI-A, BSI-D and FA variables) in step 1. None of the predictors led to a significant improvement in the regression equation. T1 health anxiety was a unique predictor of T2 health anxiety in each of the final models.

When health anxiety was entered in step 2 as a predictor of T2 light-absent and light-present FA change there was a significant improvement in the regression equations.

However, it is interesting to note that T1 light-absent and light-present FA change were not unique predictors of T2 FA change, unlike T1 B2 FAs which were significant predictors of T2 B2 FAs. Health anxiety was not a unique predictor of T2 B2 FAs.

Table D.20 Hierarchical multiple regression analyses predicting T2 false alarm (FA) variables; from T1 health anxiety controlling for T1: age, gender, medical conditions (CCI), symptom reporting (PHQ-15), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and FA variables (n = 70).

	T2: FA variables											
	B2 LA FAs			B2 LP FAs			LA FA change			LP FA change		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Step 1:												
Cons.	0.11	0.12	-	-0.08	0.15	-	-0.04	0.11	-	-0.04	0.15	-
Age	0.00	0.00	-.01	-0.00	0.00	-.10	0.00	0.00	.08	-0.00	0.00	-.18
Gen.	0.05	0.04	.18	0.03	0.04	.08	0.03	0.03	.11	-0.03	0.05	-.08
CCI	0.08	0.04	.27	-0.02	0.05	-.06	0.01	0.03	.05	0.01	0.05	.02
PHQ-15	-0.02	0.03	-.09	0.07	0.03	.30*	-0.5	0.03	-.32	0.00	0.04	.01
STAI-T	-0.00	0.00	-.11	0.00	0.00	-.03	-0.00	0.00	-.06	-0.00	0.00	-.17
BSI-A	0.00	0.01	.06	-0.00	0.01	-.06	-0.00	0.00	-.15	-0.00	0.01	-.03
BSI-D	0.01	0.01	.21	-0.01	0.01	-.17	0.01	0.00	.29	-0.00	0.01	-.09
FAs												
B2 LA	0.43	0.16	.33*	-	-	-	-	-	-	-	-	-
B2 LP	-	-	-	0.96	.21	.50**	-	-	-	-	-	-
LA Change	-	-	-	-	-	-	0.19	0.15	.16	-	-	-
LP Change	-	-	-	-	-	-	-	-	-	0.08	0.21	.05
Step 2:												
HAI	-0.00	0.02	-.01	0.01	0.03	.06	0.04	0.02	.33*	0.07	0.03	.41*
ΔR^2 (*P*)		.00 (.94)			.002 (.67)			.06 (.05)			.09 (.02)	

*p <.05. ** p <.001.

Table D.21 below displays the results of four separate hierarchical regressions taking each of the T2 false alarm variables as the target variable and health care utilisation

as the predictor in step 2, and controlling for T1 covariates (age, gender, CCI, HAI, PHQ-15, STAI-T, BSI-A, BSI-D and FA variables) in step 1. Health care utilisation was not a significant predictor of T2 FAs in any of the regression equations.

Table D. 21 Hierarchical multiple regression analyses predicting T2 false alarm (FA) variables; from T1 healthcare utilisation controlling for T1: age, gender, medical conditions (CCI), symptom reporting (PHQ-15), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and FA variables (n = 70).

	B2 LA FAs			B2 LP FAs			LA FA change			LP FA change		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Step 1:												
Cons.	0.09	.12	-	-.08	.15	-	-.04	.11	-	-.03	.15	-
Age	0.00	.00	.06	-.00	.00	-.10	.00	.00	.06	-.00	.00	-.20
Gen.	0.07	.04	.25	.03	.05	.08	.02	.03	.10	-.03	.05	-.10
CCI	0.08	.04	.27*	-.02	.05	-.06	.01	.03	.05	.01	.05	.02
PHQ-15	-0.01	.03	-.06	.07	.04	.31*	-.05	.03	-.33	-.00	.04	-.01
HAI	0.00	.02	.03	.01	.03	.06	.04	.02	.32	.07	.03	.39
STAI-T	-0.00	.00	-.08	.00	.00	-.03	-.00	.00	-.06	-.00	.00	-.18
BSI-A	0.00	.01	.08	-.00	.01	-.06	-.00	.00	-.16	-.00	.00	-.04
BSI-D	0.00	.01	.20	-.01	.01	-.17	.01	.00	.29	-.00	.00	-.09
FAs												
B2 LA	0.46	.16	.35*	-	-	-	-	-	-	-	-	-
B2 LP	-	-	-	.96	.21	.50**	-	-	-	-	-	-
LA Change	-	-	-	-	-	-	.18	.16	.15	-	-	-
LP Change	-	-	-	-	-	-	-	-	-	.08	.21	.05
Step 2:												
HCU	-0.07	0.05	-.21	-.00	.06	-.01	.01	.04	.04	.03	.06	.07
ΔR^2 (*P*)		.03 (.15)			.00 (.96)			.00 (.78)			.00 (.65)	

*p <.05. ** p <.001.

D.6. Attention and somatic awareness – exploratory analysis

Table D.22 and Table D.23 below display the results of six separate hierarchical regressions taking T2 tactile threshold as the target variable and T2 MBT performance variables as predictors in step 2, and with covariates (age, gender, CCI, PHQ-15, HAI, STAI-T, BSI-A, BSI-D and neutral-scene performance) in step 1. None of the tactile

disengagement variables significantly improved the regression equation. However, when tactile performance in threatening and neutral body-relevant conditions were included in the regression equations the predictive power of neutral body-irrelevant performance increased such that it became a positive unique predictor. Age and anxiety were also positive unique predictors. This suggests that poorer disengagement in the neutral body-irrelevant condition and increased age and anxiety are associated with less sensitive tactile thresholds.

The inclusion of visual performance in the threatening body-irrelevant condition led to a significant improvement in the predictive power of the regression equation. The direction of the coefficient was positive which suggests that poorer visual disengagement in this condition was associated with less sensitive tactile thresholds. The inclusion of threatening body-irrelevant performance also led to a simultaneous improvement in the predictive power of neutral body-irrelevant visual performance and trait anxiety, such that trait anxiety became a significant positive predictor. When visual performance in neutral and threatening body-relevant conditions were included there was not a significant improvement in the regression equations, however, in line with analysis of tactile performance age and anxiety were positive unique predictors.

Table D. 22 *Hierarchical multiple regression analyses predicting T2 tactile threshold from T2: MBT tactile performance variables, controlling for age, gender, medical conditions (CCI), symptom reporting (PHQ-15) health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A), depression (BSI-D) and neutral-scene performance (n=70).*

Average tactile threshold									
	Model 1			Model 2			Model 3		
Variable	B	SEB	β	B	SEB	β	B	SEB	β
Constant	-8928.82	2386.65	-	-9023.02	2404.67	-	-9718.70	2425.14	-
Age	20.08	7.87	.29*	21.31	8.06	.31*	18.83	8.06	.27*
Gender	205.59	174.15	.14	146.79	170.52	.10	126.07	173.53	.08
CCI	-50.61	157.40	-.04	-30.36	157.58	-.02	-19.51	161.83	-.01
PHQ-15	-25.01	123.53	-.03	-12.14	125.08	-.02	-34.22	126.84	-.04
HAI	-193.02	111.16	-.26	-211.29	.112.37	-.29	-193.22	114.62	-.26
STAI-T	15.98	8.58	.27	15.62	8.66	.27	16.60	8.82	.29
BSI-A	59.78	24.68	.45*	59.37	24.88	.44*	55.36	25.27	.41*
BSI-D	-17.83	23.08	-.15	-19.67	23.36	-.17	-16.75	23.96	-.14
Tactile targets									
Neutral-scene	7215.71	2851.48	.89*	5364.82	2177.60	.67*	1500.66	2834.53	.19
Neutral-body	-5269.19	2878.36	-.65	-	-	-	-	-	-
Threat-body	-	-	-	-3343.59	2133.25	-.42	-	-	-
Threat-scene	-	-	-	-	-	-	786.29	2742.26	.10
ΔR^2 (*P*)		.03 (.07)			.03 (.12)			.00 (.78)	

*p <.05. ** p <.001.

Table D.23 *Hierarchical multiple regression analyses predicting T2 tactile threshold from T2: MBT visual performance variables, controlling for age, gender, medical conditions (CCI), symptom reporting (PHQ-15) health anxiety (HAI), trait anxiety (STAI-T), anxiety (BSI-A) depression (BSI-D) and neutral-scene performance. (n = 70).*

Average tactile threshold									
	Model 1			Model 2			Model 3		
Variable	B	SE B	β	B	SE B	β	B	SE B	β
Constant	-7841.09	2783.23	-	-8225.93	2816.15	-	-10685.72	2809.24	-
Age	18.39	8.34	.26*	19.94	8.67	.29*	14.64	8.11	.21
Gender	182.02	185.30	.12	138.75	184.56	.09	207.64	176.10	.14
CCI	33.47	163.13	.02	11.62	164.42	.01	12.05	155.21	.01
PHQ-15	-23.28	130.14	-.03	-19.87	132.34	-.02	-12.02	124.55	-.01
HAI	-222.07	118.32	-.30	-195.89	119.04	-.27	-178.73	110.96	-.24
STAI-T	17.68	9.02	.30	16.84	9.12	.29	20.96	8.74	.36*
BSI-A	57.71	25.62	.43*	57.69	25.96	.43*	41.61	25.22	.31
BSI-D	-13.33	24.11	-.11	-15.51	24.37	-.13	-21.45	23.10	-.18
Visual targets									
Neutral-scene	-1308.21	2546.88	-.15	1128.64	2566.62	.13	-4308.09	2435.05	-.48
Neutral-body	2865.36	2236.98	.36	-	-	-	-	-	-
Threat-body	-	-	-	551.50	2433.88	.07	-	-	-
Threat-scene	-	-	-	-	-	-	6875.46	2550.58	.77*
ΔR^2 (*P*)		.02 (.21)			.00 (.82)			.07 (.01)	

*p <.05. ** p <.001.

Appendix E: Supplementary Analysis - Mood and Bodily Symptoms Study

E.1. Data analyses

Data were screened for normality; non-normal data and their transformations are displayed in Table C.1 and C.2 below.

Table E. 1 Non-normally distributed variables and their transformations

Variable	Shapiro-Wilk *W*	*p*	Transformation	Shapiro-Wilk *W*	*p*
Age	.66	.00	Unable to transform	-	-
Questionnaires					
PHQ-15	.97	.02	Square root	.98	.05
HAI	.96	.01	Square root	.98	.20
STAI-T	.96	.01	Log	.98	.06
PHQ-9	.89	.00	Unable to transform	-	-
GAD-7	.91	.00	Unable to transform	-	-
Pre MBT					
Mood	.90	.00	Log	.97	.01
Symptoms	.93	.00	Log	.97	.01
Post MBT					
Mood	.94	.00	Square root	.96	.01
Symptoms	.89	.00	Square root	.97	.03
Pre Induction					
Mood	.82	.00	Log	.95	.01
Symptoms	.85	.00	Log	.96	.01
Post Induction					
Mood	.96	.01	Square root	.96	.01
Symptoms	.87	.00	Log	.97	.02
MBT					
Picture threat ratings					
-Neutral-body	.76	.00	Unable to transform		
-Neutral-scene	.63	.00	Unable to transform		
-Threat-body	.95	.00	Unable to transform		
-Threat-scene	.93	.00	Unable to transform		
Visual targets					
-Neutral-body	.96	.00	Log	.99	.29
-Neutral-scene	.95	.00	Log	.98	.11
-Threat-body	.95	.00	Log	.97	.03
-Threat-scene	.95	.00	Log	.97	.03
Tactile targets					
-Neutral-body	.96	.01	Log	.98	.23
-Neutral-scene	.92	.00	Log	.97	.04
-Threat-body	.96	.01	Log	.99	.60
-Threat-scene	.95	.00	Log	.98	.10
SSDT					
Pre- tactile threshold	.93	.00	Unable to transform		
Post- tactile threshold	.88	.00	Unable to transform		
Block1:					
Light-absent					
Hits	.95	.00	Unable to transform		
False alarms	.78	.00	Unable to transform		
Light-present					
Hits	.93	.00	Unable to transform		
False Alarms	.79	.00	Unable to transform		
d'	.97	.01	Unable to transform		
C	.97	.01	Unable to transform		
Block 2:					
Light-absent					
Hits	.94	.00	Unable to transform		
False alarms	.78	.00	Unable to transform		
d'	.97	.01	Unable to transform		
Light-present					
Hits	.90	.00	Unable to transform		
False alarms	.86	.00	Unable to transform		

Table E. 2 Final SSDT sample non-normally distributed variables and their transformations (n = 89).

Variable	Shapiro-Wilk *W*	*p*	Transformation	Shapiro- Wilk *W*	*p*
Questionnaires					
HAI	.95	.00	Square root	.98	.31
STAI-T	.94	.00	Log	.98	.25
PHQ-9	.89	.00	Unable to transform		
GAD-7	.90	.00	Unable to transform		
Pre MBT					
Mood	.90	.00	Log	.97	.05
Symptoms	.92	.00	Log	.97	.04
Post MBT					
Mood	.94	.00	Unable to transform		
Symptoms	.87	.00	Square root	.97	.03
Pre induction					
Mood	.79	.00	Unable to transform		
Symptoms	.82	.01	Unable to transform		
Post Induction					
Mood	.96		Unable to transform		
Symptoms	.87	.00	Log	.97	.06
SSDT					
Post tactile threshold	.92	.00	Unable to transform		
Block1: Light-absent					
Hits	.95	.03	Unable to transform		
False alarms	.85	.00	Unable to transform		
Light-present					
False Alarms	.83	.00	Unable to transform		
Block 2: Light-absent					
Hits	.95	.02	Unable to transform		
False alarms	.81	.00	Unable to transform		
Light-present					
Hits	.91	.00	Unable to transform		
False alarms	.81	.00	Unable to transform		

E.2. Tactile threshold

The tactile threshold taken before (pre) the experimental phase (Mdn = -2850.00) was significantly higher than the tactile threshold taken after (post) the experimental phase (*Mdn* = -2950.00; *z* = -2.38, *p* =.02). The tactile thresholds derived in the second threshold procedure appear to have been more sensitive. The test-retest correlation was $r_{s\,=}$ .78 and indicated that the threshold was reliably determined.

E.3. SSDT results

Descriptive statistics for SSDT performance in block 1 and 2 and for light-absent and light-present trials are displayed in Table E.3 below.

Table E. 3 Median (IQR), hit rate, false-alarm rate, d' (sensitivity) and c (response bias) light-absent and light-present conditions of the SSDT (n=107).

	% hits	**% false alarms**	***d'***	***c***
Block 1				
Light-absent	64.29 (43.00)	11.90 (19.00)	1.60 (1.00)[a]	.46 (.58)[a]
Light-present	69.05 (33.00)	11.90 (14.00	1.68 (1.18)	.25 (.50)
Block 2				
Light-absent	64.29 (48.00)	7.14 (14.00)	1.58 (1.62)	.55 (.59)[a]
Light-present	73.81 (38.00)	11.90 (14.00)	1.82 (1.02)[a]	.28 (.57)[a]

[a] means (S.D.) are given because data were normally distributed

The effect of block

Light-absent false alarms and tendency to say yes both significantly decreased in block 2. There were no other significant differences between blocks (light-absent, hit rate: *z* = -.77, *p*=.44; false alarm rate: *z* = -2.95, *p*= .003; *d*': *z* = -.23, *p*=.31,; criterion: *t* = -2.04, *p*=.044; Light-present, hit rate: *z* = -.41, *p*=.68; false alarm rate: *z* = -.04, *p*= .97; *d'* : *t* = -.21, *p* =.83; *c*: *t* = -.16, *p*=.87).

The effect of light

In block 1 participants' hit rate (*z* = -5.04, *p*=.00), sensitivity (*d'*) (*z* = -3.40, *p*=.001) and tendency to say yes (*c*) (*t* = 4.62, *p*=.000) were significantly increased by the

presence of the visual stimulus. However, false alarm rate (z =-.87, p = .383) was not significantly increased by the presence of the light.

In block 2 participants' hit rate (z = -5.98, p = .00), false alarm rate, (z = -3.75, p = .00) sensitivity (t = -2.75, p = .007), and tendency to say (t = 7.50, p = .00) were all significantly increased by the presence of the light.

Correlations were performed between block 1 and 2 light-present and light-absent false alarms and hits. False alarm rate was significantly correlated between block 1 and 2 light-absent and light-present trials (see Table E.4). The only significant correlation between hits and false alarms was between block 1 light-absent hits and block 2 light-absent false alarms.

Table E. 4 Correlations between false alarms (FAs) and hits in light-absent (LA) and light-present (LP) trials for blocks 1 (B1) and 2 (B2).

			FAs				**Hits**			
			B1		B2		B1		B2	
			LA	LP	LA	LP	LA	LP	LA	LP
FAs	B1	LA	-	.598**	.586**	.454**	.128	-.010	.025	.000
		LP		-	.412**	.489**	.036	.048	-.132	-.153
	B2	LA			-	.560**	.214*	.060	.124	.084
		LP				-	.020	-.006	.006	.083
Hits	B1	LA					-	.797**	.686**	.618**
		LP						-	.669**	.674**
	B2	LA							-	.863**
		LP								-

Zero-order correlations were performed between pre and post experimental phase tactile thresholds and questionnaires and revealed no significant correlations (see Table E.5 below).

Table E. 5 Correlations between tactile threshold pre and post the experimental phase of the SSDT and questionnaires (n=107).

	PHQ-15	HAI	STAI-T	GAD-7	PHQ-9
Pre- tactile threshold	.075	-.075	.141	.025	.095
Post- tactile threshold	-.049	-.194	.143	-.134	.053

Correlations were conducted between block 1 SSDT performance and questionnaires and revealed significant correlations between light-present hit rates, tendency to say yes and symptom reporting (see Table E.6)

Table E. 6 Correlations between block 1 SSDT variables in light-absent (LA) and light-present (LP) conditions, and questionnaire measures.

	B1							
	LA				LP			
	HR	FA	*d'*	*c*	HR	FA	*d'*	*c*
PHQ-15	.135	.052	.099	-.161	.210*	.084	.132	-.211*
HAI	.097	.040	-.004	-.107	.078	.117	.002	-.114
STAI-T	.131	-.055	.109	-.045	.173	-.014	.128	-.113
GAD-7	.004	.000	.021	-.005	.129	.056	.058	-.124
PHQ-9	.063	.015	.047	-.064	.157	.156	.020	-.209

Spearman's correlations were conducted between block 2 SSDT performance and questionnaires and revealed significant correlations between SSDT parameters and questionnaire measures (see Table E.7 below)

Table E. 7 *Correlations between block 2 SSDT parameters in light-absent (LA) and light-present (LP) conditions, and questionnaire measures.*

	B2							
	LA				LP			
	Hits	FAs	*d'*	*c*	Hits	FAs	*d'*	*c*
PHQ-15	.147	-.015	.125	-.135	.108	.053	.094	-.136
HAI	.026	.009	-.010	-.041	.023	.183	-.091	-.094
STAI-T	.110	-.112	.125	-.021	.144	.055	.048	-.096
GAD-7	.053	-.115	.077	-.006	.027	.000	.040	-.071
PHQ-9	.123	-.098	.153	-.080	.090	-.031	.099	-.084

Significant correlations between SSDT variables and questionnaire measures were found only for block 1 and false alarm rate was significantly different in light-absent trials between blocks 1 and 2. Therefore change in false alarm rate between blocks 1 and 2 (B2 FAs – B1 FAs) was calculated for light-absent and light-present trials separately. These false alarm change variables were then correlated with sample characteristics and are displayed in Table E.8 below. There were no significant correlations between change in false alarm rate and questionnaires.

Table E. 8 *Correlations between light-absent (LA) and light-present (LP) change in false alarm rate and sample characteristics*

False alarms	PHQ-15	HAI	STAI-T	GAD-7	PHQ-9
LA change	-.032	-.090	.001	-.104	-.129
LP change	-.018	.022	.081	-.063	-.149

Table E.9 below displays the results of hierarchical regressions taking post-induction symptoms total as the target variable and change in mood as the predictor in step 2, and with covariates in step 1. Change in mood and pre- induction symptom experience were significant unique predictors of post- induction symptom experience.

Table E. 9 *Hierarchical multiple regression analysis predicting post-induction symptom experience from change in mood (in response to mood induction), controlling for age, gender, health anxiety (HAI), trait anxiety (STAI-T), anxiety (GAD-7) and depression (PHQ-9) and pre- induction symptom experience. (n = 89).*

	Model 1		
Variables	B	SE B	β
Constant	-0.07	0.54	-
Age	-0.01	0.02	-.05
Gender	-0.12	0.07	-.13
HAI	0.02	0.03	.05
STAI-T	0.54	0.33	.13
GAD-7	0.00	0.01	.02
PHQ-9	-0.00	0.01	-.01
Pre- induction symptoms	0.03	0.00	.72**
Mood change	0.02	0.00	.35**
ΔR^2 (*P*)		.11 (.00)	

*p <.05. ** p <.001.

Table E.10 below displays the results of five separate hierarchical regressions taking PHQ-15 total as the target variable and tactile threshold, and false alarm variables as predictors in step 2, and with covariates in step 1. None of the predictors led to a significant improvement in the regression equation. Gender and anxiety were unique predictors of symptom reporting in the final models.

Table E. 10 *Hierarchical multiple regression analyses predicting symptom reporting from tactile threshold and false alarm (FA) variables, controlling for age, gender, health anxiety (HAI), trait anxiety (STAI-T), anxiety (GAD-7) and depression (PHQ-9). (n = 89).*

Symptom reporting															
	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Cons.	6.70	8.69	-	7.12	6.40	-	8.27	6.42	-	6.55	6.23	-	7.64	6.17	-
Age	-.33	.25	-.15	-.17	.21	-.07	-.19	.21	-.08	-.14	.21	-.06	-.15	.21	-.06
Gen.	1.23	1.04	.12	1.69	.78	.17*	1.66	.78	.17*	1.88	.79	.19*	1.81	.78	.18*
HAI	.10	.45	.02	.32	.36	.08	.35	.36	.08	.25	.36	.06	.24	.36	.06
STAI-T	.03	5.14	.00	-1.73	3.85	-.04	-2.14	3.88	-.05	-1.87	3.77	-.05	-2.36	3.78	-.06
GAD-7	.52	.12	.54**	.52	.10	.54**	.52	.10	.54**	.53	.10	.56**	.54	.10	.56**
PHQ-9	.23	.11	.26*	.15	.08	.18	.15	.09	.19	.14	.08	.17*	.14	.08	.17*
Tac. Thresh.	.00	.00	-.09	-	-	-	-	-	-	-	-	-	-	-	-
FAs															
B1 LP	-	-	-	1.54	2.29	.05	-	-	-	-	-	-	-	-	-
B1 LP	-	-	-	-	-	-	-.17	2.43	-.01	-	-	-	-	-	-
B2 LA	-	-	-	-	-	-	-	-	-	4.84	3.19	.12	-	-	-
B2 LP	-	-	-	-	-	-	-	-	-	-	-	-	3.27	2.35	.11
ΔR^2 (*P*)	.01 (.38)			.00 (.50)			.00 (.95)			.01 (.13)			.01 (.17)		

*p <.05. ** p <.001.

Table E.11 below displays the results of four separate hierarchical regressions taking PHQ-15 total and HAI total as the target variable and false alarm change variables as predictors in step 2, and with covariates in step 1. None of the predictors led to a significant improvement in the regression equation. Gender and anxiety were unique predictors of symptom reporting in the final models. Age was a unique predictor of health anxiety in the final models.

Table E. 11 *Hierarchical multiple regression analyses predicting symptom reporting and health anxiety from false alarm (FA) change variables, controlling for age, gender, health anxiety (HAI), trait anxiety (STAI-T), anxiety (GAD-7) and depression (PHQ-9). (n = 89).*

	Symptom reporting						Health anxiety					
	Model 1			Model 2			Model 3			Model 4		
	B	SE B	B	B	SE B	β	B	SE B	β	B	SE B	β
Cons.	2.54	1.21	-	2.72	1.20	-	-1.64	2.01	-	-1.30	2.01	-
Age	-.03	.04	-.07	-.03	.04	-.06	.14	0.06	.24*	.14	0.06	.24*
Gend.	.35	.15	.19*	.37	.15	.20*	-0.12	0.25	.05	.15	0.25	.07
HAI	.09	.07	.12	.08	.07	.10	-	-	-		-	-
PHQ-15	-	-	-	-	-	-	0.24	0.18	-.19	0.22	0.18	.17
STAI-T	-.23	.74	-.03	-.38	.74	-.05	1.12	1.19	.12	0.89	1.21	.09
GAD-7	.09	.02	.50*	.09	.02	.51*	0.04	0.04	.17	0.04	0.04	.19
PHQ-9	.03	.02	.17	.03	.02	.19	-0.01	0.03	-.07	-0.01	0.03	-.06
FA Change												
LA	.31	.54	.05	-	-	-	-0.00	0.88	.00	-	-	-
LP	-	-	-	.60	.42	.11	-	-	-	0.57	0.69	.09
ΔR^2 (*P*)		.00 (.57)			.01 (.16)			.00 (.99)			.01 (.41)	

*p <.05. ** p <.001.

Table E.12 below displays the results of six separate hierarchical regressions taking HAI total as the target variable and tactile threshold, and false alarm variables as predictors in step 2, and with covariates in step 1. None of the predictors led to a significant improvement in the regression equation. However, Block 2 light-present FAs were a near significant predictor of health anxiety. Furthermore, of the covariates age was a unique predictor of health anxiety in the final models.

Table E. 12 *Hierarchical multiple regression analyses predicting health anxiety from tactile threshold (n =55) and false alarm (FA) variables, controlling for age, gender, health anxiety (HAI), trait anxiety (STAI-T), anxiety (GAD-7) and depression (PHQ-9). (n = 89).*

Health anxiety															
	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Cons.	-4.82	2.73	-	-1.82	2.00	-	-1.73	2.01	-	-1.75	1.95	-	-1.42	1.93	-
Age	.18	.08	.32*	.15	.07	.25*	.15	.07	.24*	.15	.06	.25*	.15	.06	.25*
Gend.	.14	.34	.05	.16	.25	.13	.14	.25	.06	.23	.25	.10	.22	.25	.09
HAI	.01	.05	.04	.03	.03	.14	.03	.03	.14	.02	.04	.10	.02	.03	.10
STAI-T	2.56	1.62	.25	1.31	1.19	.19	1.31	1.200	.14	1.17	1.17	.12	.98	1.17	.10
GAD-7	.04	.05	.18	.04	.04	-.08	.04	.04	.19	.05	.04	.23	.06	.04	.24
PHQ-9	-.04	.04	-.17	-.02	.03	.11	-.02	.03	-.09	-.02	.03	-.08	-.02	.03	-.08
Tac. Thresh.	.00	.00	-.22	-	-	-	-	-	-	-	-	-	-	-	-
FAs															
B1 LA	-	-	-	.77	.71	.11	-	-	-	-	-	-	-	-	-
B1 LP	-	-	-	-	-	-	.63	.75	.09	-	-	-	-	-	-
B2 LA	-	-	-	-	-	-	-	-	-	1.58	.99	.16	-	-	-
B2 LP	-	-	-	-	-	-	-	-	-	-	-	-	1.30	.72	.18
ΔR^2 (*P*)	.04 (.11)			.01 (.28)			.01 (.40)			.02 (.12)			.03 (.08)		

*$p < .05$. ** $p < .001$.

Table E.13 below displays the results of four separate hierarchical regressions taking PHQ-15 total as the target variable and tactile performance on the MBT as predictors in step 2, and with covariates in step 1. None of the predictors led to a

significant improvement in the regression equation. Gender and anxiety were unique predictors of symptom reporting in the final models.

Table E. 13 *Hierarchical multiple regression analyses predicting symptom reporting from tactile performance on the MBT, controlling for age, gender, health anxiety (HAI), trait anxiety (STAI-T), anxiety (GAD-7) and depression (PHQ-9) (n = 89).*

Symptom reporting												
	Model 1			Model 2			Model 3			Model 4		
Variable	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Constant	1.91	2.29	-	2.05	2.32	-	1.93	2.37	-	2.22	2.34	-
Age	0.04	0.04	.07	0.04	0.04	.07	0.04	0.04	.07	0.04	0.04	.07
Gender	0.37	0.13	.20*	0.38	0.14	.21*	0.37	0.14	.20*	0.38	0.14	.21*
HAI	0.12	0.07	.15	0.12	0.07	.14	0.12	0.07	.15	0.12	0.07	.15
STAI-T	-0.24	0.67	-.03	-0.29	0.68	-.04	-0.25	0.68	-.03	-0.31	0.68	-.04
GAD-7	0.09	0.02	.47*	0.09	0.02	.48*	0.09	0.02	.47*	0.09	0.02	.48*
PHQ-9	0.03	0.02	.16	0.03	0.02	.15	0.03	0.02	.16	0.02	0.02	.15
Tactile targets												
Neutral-scene	-0.28	0.70	-.03	0.38	1.63	.04	-0.22	1.59	-.02	0.52	1.37	.05
Neutral-body	-	-	-	-0.71	1.57	-.08	-	-	-	-	-	-
Threat-scene	-	-	-	-	-	-	-0.06	1.58	-.01	-	-	-
Threat-body	-	-	-	-	-	-	-	-	-	-0.90	1.32	-.10
ΔR^2 (*P*)	.00 (.69)			.00 (.65)			.00 (.97)			.00 (.50)		

*$p < .05$. ** $p < .001$.

Table E.14 below displays the results of four separate hierarchical regressions taking PHQ-15 total as the target variable and visual performance on the MBT as predictors in step 2, and with covariates in step 1. None of the predictors led to a significant improvement in the regression equation. Gender and anxiety were unique predictors of symptom reporting in the final regression equations.

Table E. 14 *Hierarchical multiple regression analyses predicting symptom reporting from tactile performance on the MBT, controlling for age, gender, health anxiety (HAI), trait anxiety (STAI-T), anxiety (GAD-7) and depression (PHQ-9) (n = 89).*

Symptom reporting												
	Model 1			Model 2			Model 3			Model 4		
Variable	B	SE B	B	B	SE B	β	B	SE B	β	B	SE B	β
Constant	2.68	2.30	-	4.40	2.48	-	2.60	2.36	-	2.64	2.33	-
Age	0.04	0.04	.07	0.04	0.04	.07	0.04	0.04	.07	0.04	0.04	.07
Gender	0.37	0.13	.20*	0.39	0.13	.22*	0.37	0.13	.20*	0.37	0.13	.20*
HAI	0.12	0.07	.15	0.12	0.07	.14	0.12	0.07	.15	0.13	0.07	.15
STAI-T	-0.28	0.67	-.04	-0.48	0.68	-.06	-0.28	0.68	-.04	-0.28	0.68	-.04
GAD-7	0.09	0.02	.48**	0.09	0.02	.49**	0.09	0.02	.48**	0.09	0.02	.48**
PHQ-9	0.03	0.02	.16	0.03	0.02	.18	0.03	0.02	.16	0.03	0.02	.16
Visual targets												
Neutral-scene	-0.57	0.73	-.06	1.58	1.41	.16	-0.85	1.76	-.09	-0.78	1.55	-.08
Neutral-body	-	-	-	-2.66	1.50	-.25	-	-	-	-	-	-
Threat-scene	-	-	-	-	-	-	0.31	1.77	.03	-	-	-
Threat-body	-	-	-	-	-	-	-	-	-	0.22	1.46	.02
ΔR^2 (*P*)		.00 (.43)			.02 (.08)			.00(.86)			.00 (.88)	

*$p < .05$. ** $p < .001$.

Table E.15 below displays the results of four separate hierarchical regressions taking HAI total as the target variable and tactile performance on the MBT as predictors in step 2, and with covariates in step 1. None of the predictors led to a significant improvement in the regression equation. However, tactile performance in the neutral scene condition became a significant predictor when neutral body performance was entered in the regression equation.

Table E. 15 *Hierarchical multiple regression analyses predicting health anxiety from tactile performance on the MBT, controlling for age, gender, symptom reporting (PHQ-15), trait anxiety (STAI-T), anxiety (GAD-7) and depression (PHQ-9) (n = 89).*

Health anxiety												
	Model 1			Model 2			Model 3			Model 4		
Variable	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Constant	-4.40	3.44	-	-3.57	3.46	-	-4.42	3.57	-	-4.71	3.52	-
Age	0.04	0.06	.06	0.05	0.06	.08	0.04	0.06	.06	0.04	0.06	.06
Gender	-0.01	0.21	-.01	0.06	0.21	.03	-0.01	0.21	-.01	-0.02	0.21	-.01
PHQ-15	0.28	0.15	.24	0.26	0.15	.22	0.28	0.15	.24	0.28	0.15	.24
STAI-T	1.63	1.00	.18	1.39	1.01	.16	1.64	1.02	.18	1.70	1.02	.19
GAD-7	0.03	0.03	.16	0.04	0.03	.17	0.03	0.03	.16	0.03	0.03	.15
PHQ-9	-0.02	0.02	-.10	-0.02	0.02	-.11	-0.02	0.02	-.10	-0.02	0.02	-.09
Tactile targets												
Neutral-scene	1.46	1.05	.13	4.67	2.39	.41*	1.42	2.40	.12	0.65	2.10	.06
Neutral-body	-	-	-	-3.46	2.32	-.31	-	-	-	-	-	-
Threat-scene	-	-	-	-	-	-	0.04	2.38	.00	-	-	-
Threat-body	-	-	-	-	-	-	-	-	-	0.91	2.00	.08
ΔR^2 (*P*)	.02 (.17)			.02 (.14)			.00 (.99)			.00 (.65)		

*$p < .05$. ** $p < .001$.

Table E.16 below displays the results of four separate hierarchical regressions taking HAI total as the target variable and visual performance on the MBT as predictors in step 2, and with covariates in step 1. None of the predictors led to a significant improvement in the regression equation.

Table E. 16 Hierarchical multiple regression analyses predicting symptom reporting from tactile performance on the MBT, controlling for age, gender, symptom reporting (PHQ-15), trait anxiety (STAI-T), anxiety (GAD-7) and depression (PHQ-9) (n = 89).

Health anxiety												
	Model 1			Model 2			Model 3			Model 4		
Variable	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Constant	-3.93	3.50	-	-3.79	3.86	-	-4.65	3.54	-	-3.85	3.53	-
Age	0.03	0.06	.05	0.03	0.06	.05	0.04	0.06	.06	0.03	.06	.05
Gender	-0.02	0.21	-.01	-0.02	0.21	-.01	-0.04	0.21	-.02	-0.02	.21	-.01
HAI	0.29	0.15	.24	0.28	0.15	.24	0.28	0.15	.23	0.29	.15	.24
STAI-T	1.67	1.01	.19	1.65	1.03	.19	1.57	1.01	.18	1.68	1.01	.19
GAD-7	0.03	0.03	.15	0.03	0.03	.15	0.03	0.03	.16	0.03	.03	.15
PHQ-9	-0.02	0.02	-.10	-0.02	0.02	-.09	-0.02	0.02	-.10	-0.02	.02	-.09
Visual targets												
Neutral-scene	1.31	1.10	.11	1.48	2.18	.12	-1.61	2.65	-.14	1.76	2.35	.15
Neutral-body	-	-	-	-0.21	2.34	-.02	-	-	-	-	-	-
Threat-scene	-	-	-	-	-	-	3.21	2.65	.27	-	-	-
Threat-body	-	-	-	-	-	-	-	-	-	-0.48	2.22	-.04
ΔR^2 (*P*)	.01 (.23)			.00 (.93)			.01 (.23)			.00 (.83)		

*$p < .05$. ** $p < .001$.

E.4. Hierarchical regressions predicting post- induction symptoms

Table E.17 and E.18 below displays the results of five separate hierarchical regressions taking post- mood induction symptoms total as the target variable and false alarm variables and tactile threshold as predictors in step 2, and with covariates in step 1. None of the predictors led to a significant improvement in the regression equation. Pre-mood induction symptoms and trait anxiety were unique predictors of post- mood induction symptom experience in the final models.

Table E. 17 Hierarchical multiple regression analyses predicting post- mood induction symptoms from false alarm (FA) variables, controlling for age, gender, health anxiety (HAI), trait anxiety (STAI-T), anxiety (GAD-7) , depression (PHQ-9), pre- mood induction mood and symptoms. (n = 89).

Post- mood induction symptoms (n = 89)																		
	Model 1			Model 2			Model 3			Model 4			Model 5			Model 6		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Con.	-.33	.65		-.21	.65	-	-.34	.64	-	-.29	.63		-.21	.64	-	-.22	.64	-
Age	-.02	.02	-.07	-.02	.02	-.07	-.02	.02	-.06	-.02	.02	-.08	-.02	.02	-.08	-.02	.02	-.08
Gen.	-.09	.08	-.09	-.10	.08	-.10	-.09	.08	-.09	-.10	.08	-.10	-.10	.08	-.10	-.10	.08	-.10
HAI	.03	.04	.07	.03	.04	.08	.03	.04	.07	.04	.04	.08	.03	.04	.08	.03	.04	.08
STAI-T	.80	.39	.20*	.75	.39	.19*	.80	.38	.20*	.80	.38	.20*	.75	.39	.19	.75	.39	.19
GAD-7	-.00	.01	-.02	-.00	.01	-.02	-.00	.01	-.01	-.00	.01	-.03	-.00	.01	-.04	-.00	.01	-.04
PHQ-9	.00	.01	.04	.01	.01	.06	.00	.01	.04	.00	.01	.05	.00	.01	.04	.00	.01	.04
Pre-MBT mood	-.01	.01	-.05	-.00	.01	-.04	-.01	.01	-.05	-.00	.01	-.04	.05	.10	.04	.05	.10	.04
Pre-MBT Sys	.03	.00	.71**	.03	.00	.72**	.03	.00	.71**	.03	.00	.72**	.03	.00	.69*	.03	.00	.69*
<u>FAs B1</u>																		
LA	.01	.24	.00				-	-	-	-	-	-	-	-	-	-	-	-
LP	-	-	-	-.17	.25	-.05	-	-	-	-	-	-	-	-	-	-	-	-
<u>B2</u>																		
LA	-	-	-	-	-	-	.07	.33	.02	-	-	-	-	-	-	-	-	-
LP	-	-	-	-	-	-	-	-	-	-	.24	-	-	-	-	-	-	-
FAs Change.										.14		.05						
LA	-	-	-	-	-	-	-	-	-	-	-	-	.04	.28	.01	-	-	-
LP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.01	.22	.00
ΔR^2 (P)	.00 (.97)			.00 (.50)			.00 (.84)			.00 (.56)			.00 (.88)			.00 (.97)		

*p < .05. ** p < .001.

Table E. 18 *Hierarchical multiple regression analyses predicting post- mood induction symptoms from tactile threshold, controlling for age, gender, health anxiety (HAI), trait anxiety (STAI-T), anxiety (GAD-7) , depression (PHQ-9), pre-mood induction mood and symptoms. (n = 55).*

Post- induction symptoms			
	Model 1		
Variable	B	SEB	β
Constant	-16.32	15.42	-
Age	0.23	0.45	.05
Gender	-0.67	1.87	-.03
HAI	1.12	0.81	.13
STAI-T	3.63	9.07	.04
GAD-7	-0.41	0.23	-.19
PHQ-9	0.41	0.20	.21*
Pre-MBT mood	0.04	0.18	.02
Pre-MBT symptoms	1.01	0.11	.83*
Tactile threshold	-0.00	0.00	-.13
ΔR^2 (*P*)		.01 (.14)	

*$p < .05$. ** $p < .001$.

Table E.19 below displays the results of four separate hierarchical regressions taking post- mood induction symptom total as the target variable and tactile sensitivity variables as predictors in step 2, and with covariates in step 1. None of the predictors led to a significant improvement in the regression equation. Pre- mood induction symptom reporting and trait anxiety were unique predictors of post- mood induction symptom reporting in the final models.

Table E. 19 *Hierarchical multiple regression analyses predicting post-induction symptoms from visual MBT performance variables, controlling for age, gender, health anxiety (HAI), trait anxiety (STAI-T), anxiety (GAD-7) , depression (PHQ-9), pre- mood induction mood and symptoms. (n = 106).*

Post- induction symptoms (*n* = 106)									
	Model 1			Model 2			Model 3		
Variable	B	SEB	β	B	SEB	β	B	SEB	β
Constant	0.06	1.22	-	-0.05	1.14	-	-0.33	1.11	-
Age	-0.04	0.02	-.14*	-0.04	0.02	-.14*	-0.04	0.02	-.14*
Gender	-0.11	0.07	-.11	-0.11	0.07	-.11	-0.12	0.07	-.12
HAI	0.04	0.03	.08	0.04	0.03	.08	0.04	0.03	.08
STAI-T	0.77	0.33	.19*	0.80	0.33	.19*	0.77	0.32	.19*
GAD-7	-0.00	0.01	-.04	-0.00	0.01	-.04	-0.00	0.01	-.02
PHQ-9	0.00	0.01	.03	0.00	0.01	.03	0.00	0.01	.01
Pre- induction mood	-0.00	0.01	-.01	-0.00	0.01	-.01	-0.00	0.01	-.01
Pre- induction symptoms	0.03	0.00	.72**	0.03	0.00	.73**	0.03	0.00	.73**
Visual targets									
Neutral-scene	0.33	0.70	.06	0.37	0.88	.07	-1.07	0.74	-.20
Neutral-body	-0.27	0.74	-.05	-	-	-	-	-	-
Threat-scene	-	-	-	-0.28	0.88	-.05	-	-	-
Threat-body	-	-	-	-	-	-	1.27	0.70	.24
ΔR^2 (P)		.00 (.71)			.00 (.75)			.01 (.07)	

*$p < .05$. ** $p < .001$.

Table E.20 below displays the results of four separate hierarchical regressions taking post- induction symptom total as the target variable and tactile MBT performance variables as predictors in step 2, and with covariates in step 1. None of the predictors led to a significant improvement in the regression equation. Age, trait anxiety and Pre-induction symptom reporting were unique predictors of post- induction symptom reporting in the final models.

Table E. 20 Hierarchical multiple regression analyses predicting post-induction symptom reporting from tactile MBT performance variables, controlling for age, gender, health anxiety (HAI), trait anxiety (STAI-T), anxiety (GAD-7) , depression (PHQ-9), pre- MBT mood and symptoms. (n = 106).

Post- induction symptoms (n = 106)									
	Model 1			Model 2			Model 3		
Variable	B	SEB	β	B	SEB	β	B	SEB	β
Constant	-0.62	1.12	-	-.76	1.15	-	-0.57	1.13	-
Age	-0.04	0.02	-.14*	-0.04	0.02	-.13*	-0.04	0.02	-.14*
Gender	-0.12	0.07	-.12	-0.11	0.07	-.11	-0.11	0.07	-.11
HAI	0.04	0.03	.08	0.03	0.03	.07	0.03	0.03	.07
STAI-T	0.82	0.33	.20*	0.83	0.33	.20*	0.80	0.33	.20*
GAD-7	-0.01	0.01	-.05	-0.01	0.01	-.05	-0.01	0.01	-.05
PHQ-9	0.00	0.01	.03	0.00	0.01	.03	0.00	0.01	.03
Pre- induction mood	0.01	0.01	.00	0.00	0.01	.01	0.00	0.01	-.01
Pre- induction symptoms	0.03	0.00	.72**	0.03	0.00	.72**	0.03	0.00	.73**
Tactile targets									
Neutral-scene	-0.05	0.80	-.01	-0.24	0.80	-.05	0.22	0.66	.04
Neutral-body	0.35	0.77	.07	-	-	-	-	-	-
Threat-scene	-	-	-	0.57	0.80	.11	-	-	-
Threat-body	-	-	-	-	-	-	0.06	0.64	.01
ΔR^2 (P)		.00 (.65)			.00 (.48)			.00 (.93)	

*p < .05. ** p < .001.