

PERSONALITY'S INTERACTION WITH THE PAIN
EXPERIENCE

By

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Abstract

Pain is more than just a physical response to disease or injury. Pain is flexible and varies dependant on psychological state. Personality traits such as depression, hysteria and hypochondriasis can mediate pain. A wealth of research has identified the relationship between personality and pain, but each individual case only centres on specific traits or specific causes of pain. In the first experiment participants were subjected to the MMPI and tests of pain sensitivity and anomalous perception. Correlation coefficients identified a significant negative relationship between hysteria and pain threshold and a positive relationship between gender inversion and pain threshold. A significant negative relationship was observed between pain sensitivity and frequency of anomalous perceptual experiences. This finding is potentially due to a susceptibility to heightened sensory experiences and consequently pain. The second experiment centres on the induction of an anomalous perceptual experience using a modified rubber hand illusion. Participants reported significantly greater pain in the sensory-motor incongruent condition possibly due to the associated heightened sensory experience. This indicates the existence of an anomalously perceptive personality and highlights gender inversion as a new personality trait that mediates pain. Further research is required using modern methods and to test the prevalence of these personality traits in functional pain patients.

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Chapter One

**Personality: An
Overview**

The Construct of Personality

Several schools of psychology have attempted to define personality and its origins. A respected definition produced by the American Psychological Association (2010) states “Personality refers to individual differences in characteristic patterns of thinking, feeling and behaving. The study of personality focuses on two broad areas: One is understanding individual differences in particular personality characteristics, such as sociability or irritability. The other is understanding how the various parts of a person come together as a whole.” The study of these broad areas, of how personality functions as a whole and how it can be broken down into its component parts has been the centre of considerable debate. This debate is split into three core regions of interest: trait theory, type theory and psychopathology.

Trait Theory

Trait theory suggests that personality comprises of a finite number of personality traits that are exclusive of each other. These traits are associated with specific and consistent patterns

Eysenck's Model of Personality	The Big Five Personality Model	Cattell's Model of Personality
Neuroticism	Neuroticism	Warmth
Extraversion	Extraversion	Reasoning
Psychoticism*	Conscientiousness	Emotional Stability
	Agreeableness	Dominance
	Openness to Experience	Liveliness
		Rule-Consciousness
		Social Boldness
		Sensitivity
		Vigilance
		Abstractedness
		Privateness
		Apprehension
		Openness to Change**
		Self-Reliance**
		Perfectionism**
		Tension**

Notes

* - Added Eysenck & Eysenck (1985)

** - Added Cattell (1977)

Figure 1: A table displaying the personality traits that comprise Eysenck's (1985), McCrae & Costa's (1987) and Cattell's (1977) trait models.

of behaviour and consequently an individual who possesses a specific personality trait will predictably follow that traits corresponding pattern of behaviour. There are three leading trait models (See Figure 1) that all contain certain core

traits. Two personality traits, neuroticism and extraversion (see glossary for descriptions of all noted traits) have been shown to be consistently independent and exclusive of one another, resulting in their presence in many personality models (Costa & McCrae, 1976; Eysenck & Eysenck, 1985). Hans Eysenck (1947) identified these two traits as the core components of human personality, with interaction of these two traits responsible for the majority of human behaviour. This model has been heavily criticized for oversimplifying personality, as clearly individual differences are more complicated and intricate than just two independent traits. This criticism led to Eysenck's inclusion of a psychoticism scale in his refined model, which he also intended to explain schizophrenic, psychotic and idealistic personalities (Eysenck & Eysenck, 1976). Eysenck produced two measures to assess personality, the Eysenck Personality Inventory (EPI) and the Eysenck Personality Questionnaire (EPQ). The EPI, Eysenck's original personality measure, tested participant's levels of extraversion and neuroticism through the use of 24 polar (yes/no) questions. The EPQ is an extension to the EPI, comprising of a further 24 polar questions testing for psychoticism and lying. The Lie Scale specifically tests whether participants are simply providing socially desirable responses and is generally considered a validation measure rather than a test of personality (Eysenck & Eysenck, 1976). Nevertheless, the lie scale has also been utilised as a measure of social conformity in some countries (Bijnen & Poortinga, 1988; Loo, 1995). The EPQ has been successfully replicated cross-culturally, but interpretation of cross-cultural comparisons should be treated with caution to avoid cultural bias (Bijnen & Poortinga, 1988; Bijnen, Van Der Net & Poortinga, 1986). The participant's scores on the original extraversion and neuroticism scales and their modern counterparts are significantly associated, with correlations of 0.80 and 0.87 respectively (Campbell & Reynolds, 1982). These high correlations allow moderate generalisation of results from the EPI to the EPQ. Importantly Campbell & Reynolds found no relationship between psychoticism scores and the new extraversion and neuroticism scales, concluding the three personality scales are successfully testing different traits and therefore are mutually exclusive. The EPI has been criticised as being

far too narrow in its range of traits, with Krug (1978) identifying the Cattell's 16F to be the better questionnaire. Heim (1970) continues in this vein, claiming the EPI to be so narrow that it cannot warrant the term *personality test*. Heim (1970) noted that human personality cannot be evaluated by only 24 forced choice yes/no questions. This questionnaire uses twelve questions to assess each personality trait through the use of situational questions. It is not possible to adequately define an individual's personality validly or in any specific detail based upon how they behave in 24 situations. This addition only attempts to explain psychopathological components of a personality and therefore, the model needs to be broadened further.

A popular alternative of Eysenck's model is the Big Five Personality Model (Goldberg, 1993; McCrae & Costa, 1987) incorporating Eysenck's (1947) key traits: neuroticism and extraversion with the addition of conscientiousness, agreeableness and openness to experience. The Big Five Model has been successfully replicated internationally with a variety of languages (McCrae & Costa, 1997; McCrae et al., 2000) and under various questioning procedures (Ferguson, 2000). The inclusion of conscientiousness and agreeableness attempts to specify Eysenck's concept of psychoticism and apply it to participants outside of a clinical sample (McCrae & Costa, 1987). Whilst this model is traditionally applied to the general population it also has scope as a predictor of clinical psychopathology (Saulsman & Page, 2004). Saulsman and Page examined the relationship between the Big Five Personality Traits and the ten personality disorders identified in DSM-IV. Using meta-analysis Saulsman & Page noted that each DSM-IV recognised personality disorder had a specific personality profile in the Big Five model. These profiles were also reliable identifiers of each personality disorder. Whilst The Big Five Personality Model is more specific than Eysenck's theory it has still been criticised for not incorporating all feasible personality traits (Saucier & Goldberg, 1998). The Revised Neuroticism-Extraversion-Openness Personality Inventory (NEO PI-R) is a popular personality inventory that tests participant's levels of the Big Five personality traits. The NEO PI-R consists of 240 statements. Agreement to the statements is assessed with a 5-point Likert Scale, ranging from "Strongly

Disagree” to “Strongly Agree”. In circumstances where an observer is to record participant’s behaviour themselves rather than through participants self report, an equivalent observer test is provided, also consisting of 240 5-point Likert rated statements. The NEO PI-R has generalised well internationally (Aluja, Rossier, Garcia & Verandi, 2005; Egger, De May, Derkson & van der Staak, 2003; McCrae et al., 2005; Piedmont & Chae, 1997; Yang et al., 1999) and with psychiatric patients (Egger et al., 2003; Yang et al., 1999).

A more specific, larger trait model was proposed by Cattell (1965, 1977) identifying sixteen mutually exclusive personality traits. As this model comprises of 16 traits (Shown in Figure 1) it is clearly more specific than Eysenck’s and McCrae & Costa’s models. This model has been refined over many years, through the use of personality questionnaires and factor analysis, enhancing the definitions of the sixteen personality traits (Cattell, 1946; 1965; 1977; Cattell & Cattell, 1995). The Big Five personality traits also feature in Cattell’s model (under different names) and are considered to be the five traits out of the sixteen that have the greatest influence on behaviour. The Sixteen Personality Factor Questionnaire (16PF) has been developed by Cattell to test participant’s levels of the personality traits outlined in Cattell’s 16 trait model. The 16PF uses 185 multiple choice everyday situation based questions. Aluja et al. (2005) found the French and Spanish versions of the 16PF not to replicate the results obtained in the US, indicating poor cross-cultural generalisability. Saville & Blinkhorn (1981) comprehensively tested the 16PF with over 3000 participants. Factor analysis of participants test results identified only seven of Cattell’s sixteen personality factors to be homogenous, with 9 factors failing to remain exclusive of each other. As Cattell’s model is based upon this homogeneity it is likely the model requires revision. Baird (1981) contests the reliability of the 16PF, finding the mean reliability of 70 participants scores on the 16PF over a 9 month period to be 0.47. This reliability is considerably lower than Cattell’s original mean reliability of 0.74 (Cattell, 1965). This finding is concerning as trait theorists argue that personality is consistent and valid assessment will illustrate this consistency. Such

reliability has been observed in the EPQ (Eysenck & Eysenck, 1985) and the NEO PI-R (Trull et al., 1995).

Type Theory

Type theory approaches personality from a conflicting viewpoint to trait theory. Trait theory identifies a multitude of traits that individuals possess to a varying extent. Type theorists

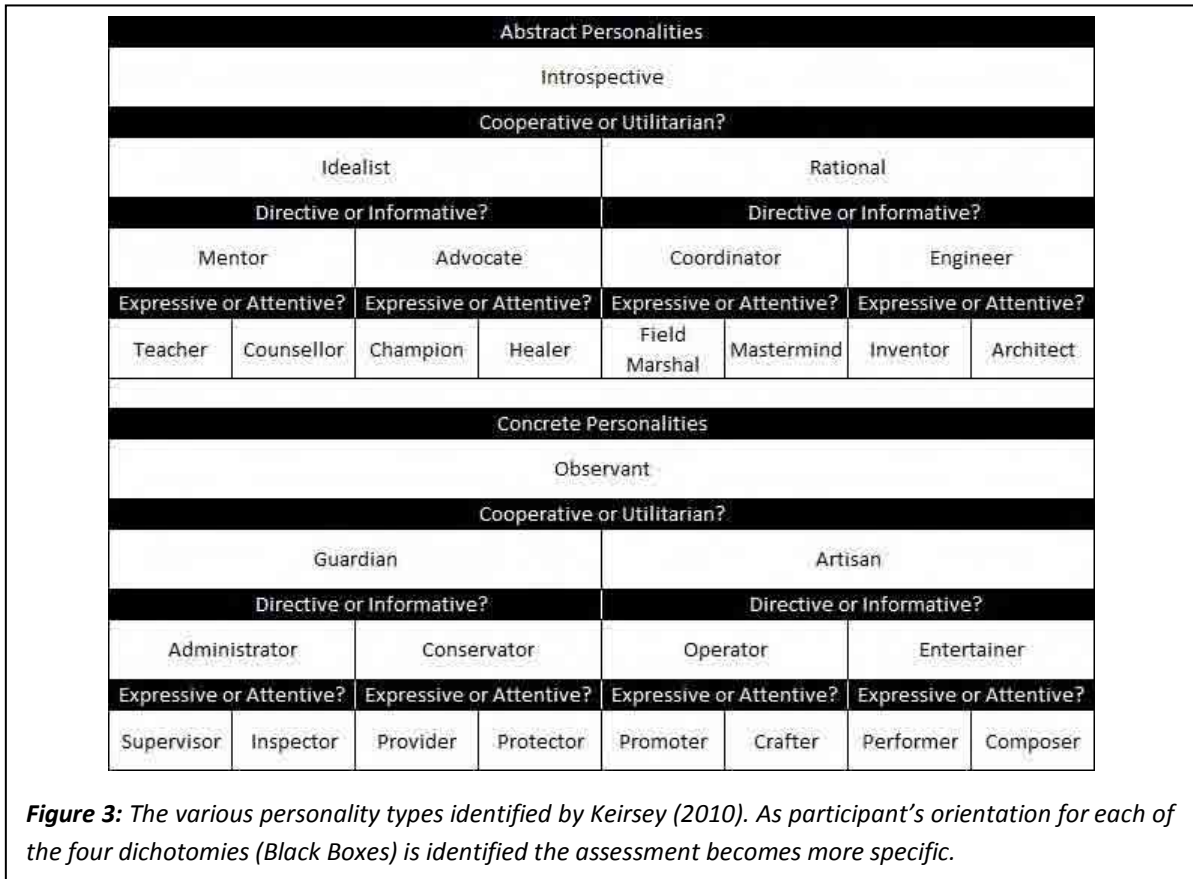
argue that personality is a collection of dichotomies with individuals possessing one trait or its polar opposite trait with no gradient of strength in between. Consequently type theorists would argue that two individuals with the same personality type will possess that type to an equal extent. An early type theory developed by Carl Jung identified extraversion vs. introversion, sensing vs. intuition and thinking

		Sensing		Intuition (N)		
Introversion		ISTJ 11-14%	ISFJ 9-14%	INTJ 2-4%	INFJ 1-3%	Judgement
		ISTP 4-6%	ISFP 5-9%	INTP 3-5%	INFP 4-5%	Perception
Extraversion		ESTJ 8-12%	ESFJ 9-13%	ENTJ 2-5%	ENFJ 2-5%	Judgement
		ESTP 4-5%	ESFP 4-9%	ENTP 2-5%	ENFP 6-8%	Perception
		Thinking	Feeling	Thinking	Feeling	

Figure 2: Myers & Myers (1995) sixteen personality types devised from the combinations of four dichotomies. The percentage of the population possessing each personality type is shown below each type.

vs. feeling as three pairs of personality dichotomies that define the whole human personality (Jung, 1971). Jung argued that all individuals will possess one of each of the personality types in each pair, with each type possessing associated personality traits. An alteration to the model was proposed by Myers, suggesting the addition of judgement vs. perception, a dichotomy based upon lifestyle (Myers & Myers, 1995). These four dichotomies in Myer's altered model provide sixteen possible personality types (See Figure 2). The Myers-Briggs Type Indicator (MBTI) tests for

these 16 key personality types. The MBTI requires participants to complete 88 forced choice dichotomous questions. Factor analysis of 359 college students' scores on the MBTI found the measure to have high construct validity (Thompson & Borrello, 1986). Pulver & Kelly (2008) studying students yet to decide their college major found the MBTI to correctly predict almost



50% of student's future course choices. This measure clearly is an effective predictor of behaviour and is therefore a successful personality test. The Keirsey Temperament Sorter (KTS) is an alternative to the MBTI devised by David Keirsey. The KTS tests for the same 4 dichotomies and consequent personality types as the MBTI but features differing interpretations of these types. The KTS attributes temperaments and roles to each personality type in a hierarchical structure (Figure 3). Francis, Craig & Robbins (2008) tested 554 undergraduate students with the KTS and the EPQ. High concurrent validity was observed, but surprisingly a correlation was found between the KTS Extraversion/Introversion (KTS EI) and EPQ Neuroticism scales. Therefore the KTS EI scale fails to exclusively test for introversion but also anxiety and emotional instability. Revisions to the

questions or the definitions of the hierarchy may be required to compensate for this. The KTS also has strong concurrent validity with the MBTI (Kelly & Jugovic, 2001) which suggests that the hierarchy of both models require adjustment.

A simple and popular type theory, Friedman's (1996) Type A and Type B personalities, suggests that an individual's personality is either highly stressed and anxious (Type A), or persistently relaxed (Type B). Type A is characterised by a high stress level, a desire to continually achieve goals, a hatred of failure and a highly competitive nature. Type B is characterised by a relaxed nature, with little anxiety of failure and great satisfaction from success. Friedman's theory was proposed as a predictor of heart attacks, with Type A personalities enduring a greater predisposition to heart disease than Type B (Jenkins, Zyzanski & Rosenman, 1971). This theory has not been validated extensively and contains specific questions that are not applicable to all participants. One example of this is driving, as frequent road rage is a critical characteristic of a Type A personality (Friedman, 1996). Whilst this behaviour may be evidence of a Type A personality it limits attribution of this personality to individuals who drive in stressful circumstances. This model is also limited by its empirical backing, as the original investigation (Friedman & Rosenman, 1959) only studied males, utilised small sample sizes and provided no explanation of how only three personality types exist. Myers' and Keirsey's type theories provide a detailed breakdown of each individual personality type alongside large scale empirical investigation. Due to this robust nature, these two theories are likely to provide a greater evaluation of personality than Friedman's model.

Personality and Psychopathology

Psychopathology is the study of mental illness and abnormality, and commonly uses personality as a construct for diagnosis (Graham, 2005). Many mental illnesses such as paranoid personality disorder are characterised by extreme levels of a traditionally healthy personality

trait, in this case paranoia. Therefore mild levels of personality traits such as paranoia, schizophrenia, anxiety, psychopathy and depression are healthy and prevalent in the healthy population (Dahlstrom & Welsh, 1962). Research into psychopathology and personality aims to identify the personality traits associated with mental illness and the extent of these traits individuals can possess before they become harmful. This region of research concentrates on how personality can develop into a psychopathology rather than designing a complete personality model. This allows for high quality validation as the personalities of patients displaying extreme behaviours can be studied and compared to those in the healthy population. This shows which components of personality can lead to mental illness. These validated reliable personality inventories then allow physicians to establish the severity of a patient's mental illness. Two experimental measures, the Minnesota Multiphasic Personality Inventory (MMPI) and the Millon Clinical Multiaxial Inventory (MCMI) have been designed to identify levels of personality traits attributed to mental illness. The MMPI is the most widely used and studied self-report measure of personality in the world (Vendrig, 2000). It has been designed to evaluate levels of 10 clinical conditions, each relating to personality, in a similar vein as the MCMI. These 10 clinical scales are devised through criterion analysis by presenting a large pool of items to groups deemed stereotypical of each clinical scale. By studying groups' responses specific scales can be identified and the surplus discarded. These scales are then centred around scores obtained by the general population so extreme scores can be identified as of clinical concern. To allow for changes in culture and society the item pool was updated in the 1989, with the University of Minnesota producing the MMPI-2. The original MMPI and the MMPI-2 maintain high continuity allowing results from the MMPI generalisable to the present day (Ben-Porath & Butcher, 1989). The MMPI has strong construct validity with the MCMI and has generalised well internationally (Egger, De May, Derkson & van der Staak, 2003a; 2003b).

The MCMI has been designed to evaluate participants levels of traits associated with the 12 personality disorders identified by DSM-IV and a further 2 disorders featured in DSM-III-R. The

MCMI-III has strong construct validity for DSM based assessment of anxiety (Blais et al., 2003) and avoidance (Blais et al., 2003). Davis & Hays (1997) noted considerable convergent validity between the MCMI-III and the Brief Symptom Inventory in assessing depression. The same finding was observed by Goldberg, Shaw & Segal (1987) between the original MCMI and the Beck Depression Inventory. Davis & Hays did discover a significant overlap of variance between the MCMI-III's depressive, avoidance, self-defeating and major depression scales. This finding suggests that many of the scales are testing for the same behaviours. In a traditional personality test this overlap is an example of poor trait definition. The MCMI specifically tests for personality disorders. As many traits are present in multiple personality disorders this level of overlap is expected. Overholser (1990) found the MCMI to have considerable reliability when he tested clinical inpatients over 24 months. The MCMI-III has limited validity for identifying random responders (Charter & Lopez, 2002).

The Perfect Test

There is a large variety of personality tests with little consensus determining “the perfect test”. A validity scale in a personality measure is important to assess whether participants are exaggerating or providing socially desirable responses. This form of validity scale is incorporated in the MMPI (Hathaway & McKinley, 1951) and EPQ (Eysenck & Eysenck, 1985). All of the aforementioned personality inventories have theoretical backing, often through the use of factor analysis or fulfilling diagnostic criteria such as DSM-IV. All of the aforementioned inventories remain popular research measures and are frequently selected for the specific traits they can identify rather than their comprehensiveness. Therefore a sensible choice of personality test should be based upon the individual personality traits that require investigation. If a range of personality traits is to be investigated personality inventories frequently used in the specific area of research allows valid comparisons of findings.

A specific limitation of establishing an individual's personality is that you can never entirely predict their behaviour. Personality is a collection of tendencies and preferences that define the decisions an individual makes (Mischel, 1968). This definition fails to explain how an individual's current state of mind or the situation they are placed in may have a greater effect on their decision. Mischel's (1968) groundbreaking research identified that behaviour is dependent on situational cues as well as personality, leading to the foundations of the Interactionalist approach. Bowers (1973) reviewed eleven studies investigating behaviour and personality. Bowers concluded that personality explained 13% and situation explained 10% of the variance in behaviour. The interaction between the two factors explained 20% of this variance, leading Bowers to suggest the Interactionalist account of personality. The Interactionalist perspective identifies that the interaction between personality and situation defines a proportion of an individual's behaviour. With this model accurate assessment of situation in addition to personality is required to predict behaviour. This work has been contested by Eysenck & Eysenck (1980) who found strong positive correlations between personality ratings and behaviour exclusive of situation.

It is apparent that personality is a one predictor of behaviour. Many studying this field only investigate the relationship between personality and social behaviour, neglecting behaviours such as pain response. The study of pain perception and sensitivity in relation to these personality models is likely to provide greater knowledge of pain and how our individual differences mediate it.

Chapter Two

The Flexibility of Sensation

The Flexibility of Pain

Pain is a subjective sensation including affective and cognitive components mediated by experience. Consequently there is significant cultural variation in the expression and experience of pain. An East African treatment for chronic pain, for example, involves removing a portion of the scalp to expose a large region of the skull. The procedure is conducted without anaesthetic or analgesic but the patient displays no signs of pain (Melzack & Wall, 2008). This example illustrates the flexibility of pain perception, and raises the question of how we can control it. This flexibility has also been observed with psychological factors that influence pain. A series of studies have demonstrated that positive mood (De Wied & Verbaten, 2001; Villemure & Bushnell, 2002), anxiety (Keogh & Cochrane, 2002; Keogh et al., 2004) and personality (Ferracuti & De Carolis, 2005; Paine et al., 2009) have an influence on pain.

In general positive mood reduces pain and negative mood enhances pain. Weisenberg, Raz & Hener (1998), for example, presented participants with a humorous film to invoke a positive mood prior to cold pressor pain. Participants were found to have significantly greater pain tolerance after watching the humorous film when compared to those who had watched a neutral control film. Similarly, Kirwilliam & Derbyshire (2008) primed participants with unpleasant pain related images and demonstrated increased sensitivity to heat and increased report of the heat as painful.

Anxiety also has a large influence on pain (Keogh & Cochrane, 2002; Keogh et al., 2004) and may account for the effects of negative priming (De Wied & Verbaten, 2001; Kirwilliam & Derbyshire, 2008). Negatively primed participants may become anxious and consequently pay greater attention to the noxious stimulus (Mogg & Bradley, 1998) and thus report greater pain (Dickens, McGowan & Dale, 2003). Transient changes in affect or mood, therefore, can change the reported perception of pain.

The Rubber Hand Illusion

Psychological factors are not the only novel factor illustrating the flexibility of pain. Incongruent sensory input can elicit a painful response (McCabe, Haigh, Halligan & Blake, 2005), with some individuals more predisposed to this response than others (McCabe, Cohen & Blake, 2007). The rubber hand illusion is a commonly studied example of multi-sensory integration in which participants perceive the sensation of fake hand being stroked, when stroked in synchrony with their own hand (Botvinick & Cohen, 1998). This novel illusion is achieved through a cocktail of sensory input; participant's eyes see a hand being stroked, they feel their hand being stroked, and their posture replicates what they can see and feel. These sensations, working in synchrony negate any inconsistent proprioception, frequently discarding the sensation of their actual hand and reinterpreting the rubber hand as their own. Intriguingly such sensory-motor conflict has a greater effect on chronic pain patients. McCabe et al. (2007) induced an incongruent sensory-motor experience by asking Fibromyalgia patients to move their arms up and down in alternate directions continuously. Whilst performing this action participants looked at a mirror placed to the right of their head. This mirror invoked the appearance that participants right arm was performing the opposite action to the one that it was actually performing. Participants were asked to describe the sensation this incongruent experience invoked. Fibromyalgia patients felt greater amounts of discomfort, peculiarity and pain than healthy controls. This finding indicates that Fibromyalgia patients are not only sensitive to fatigue and pain but perceptual anomalies also.

Research Direction

It is clear that pain is a flexible sensation that can be mediated by psychological states. As personality defines the frequency and the means we experience these states a relationship between personality and pain is highly feasible. A vulnerability to perceptual anomalies is possibly related to pain as it is common in chronic pain patients. The relationship between pain,

personality and vulnerability to anomalous perception requires further investigation to clarify the flexibility of pain.

Chapter Three

**Personality meets
Pain**

Introduction

Personality meets Pain

Personality traits, alongside the specific situation, define how frequently an individual experiences a transient state, such as anxiety or negative mood. Due to the relationship these transient states have on pain sensitivity it is of utmost importance to understand how personality interacts with pain. As personality may change due to a life changing event such as the diagnosis and trauma of a medical condition it is troublesome to identify a causal relationship between these two factors. Due to this complication the bulk of research cannot identify personality prior to the onset of a pain condition but can simply state comorbidity of extreme personality traits and pain. A large amount of research has used the MMPI, a popular personality test, to investigate whether specific psychopathologies relate to pain sensitivity. Applegate et al. (2005) is an excellent example of an experimental design that can infer a causal relationship. Applegate et al. tested 2332 students with the MMPI at college entry providing a detailed evaluation of their personality. Thirty years later Applegate et al. undertook a follow-up requesting all participants to report any diagnosed pain conditions. Applegate et al. found hypochondriasis and hysteria positively correlated with the frequency of reported pain conditions. Additionally, they reported significantly greater pain conditions in males who scored high on the masculine/feminine scale and women who scored high on the paranoia scale. Similar research by Gatchel, Polatin & Kinney (1995) found a relationship between hysteria and pain sensitivity. Gatchel et al. administered the MMPI to 324 acute low back pain patients. A structured interview conducted 6 months later found the patients who hadn't returned to work scored significantly higher on the hysteria scale than those who had. This relationship has also been observed in chronic headache patients (Mongini et al., 2009). Patients who scored high on the hysteria scale reported significantly greater severe headaches than chronic headache patients with depressive personalities. There are two possible explanations for this result; either hysteria intensifies chronic headache or

hysteria induces a desire for malingering. Whilst Mongini et al's findings indicate a depressive personality is unrelated to pain sensitivity a wide range of evidence suggests the contrary

The prevalence of depression as a persistent illness in chronic pain patients is estimated as high as 56% (Gambassi, 2009) and as low as 3% (Gormson, Rosenberg, Bach & Jensen, 2010). On the whole, the prevalence of depressive disorders in chronic pain patients is estimated to be generally higher than incidence in the general population (16.2%; Kessler et al., 2003) but the relationship between pain and depression remains uncertain.

Longitudinal studies or studies involving experimentally induced pain provide an opportunity to directly assess the relationship between depression and pain sensitivity. Schieir et al. (2009) measured the current levels of depressive mood and pain of 180 arthritis patients. Levels of depression and pain were also recorded six months later. Comparisons between these two periods found baseline levels of depression significantly predicted the patient's pain at the six month follow-up. Although a causal relationship cannot be inferred from these findings it is clear that depression and pain are related. Experimentally induced pain scenarios indicate that depression may cause a pain sensitivity. Klauenberg et al. (2008) found inpatients suffering from various depressive disorders to display a lower thermal pain threshold, but not mechanical pain threshold, than healthy controls. This provides some evidence that depression is a component of a 'pain prone' personality as depressive patients showed a greater sensitivity to thermal pain than healthy controls. Greater investigation is required to understand why this relationship was not observed in the mechanical pain condition. Blozik et al. (2009) observed similar findings by studying neck pain patients, establishing a very strong correlation between depressive mood and severity of neck pain. Whilst only a correlational relationship can be recorded it is probable that as participants already suffered from a painful condition and only a temporary state of depression was recorded (rather than a persistent trait) it is unlikely that depression caused the neck pain in this case. Therefore it is likely that in this case depression acts as a catalyst for the neck pain,

exacerbating the condition. It is hard to study which condition presents itself first, depression or chronic pain as longitudinal studies are costly and large sample sizes are required as it is debatable how frequent they present themselves co-morbidly. Cairns, Adkins and Scott (1996) studied the interactions between the two, examining patients presenting with both depressive mood and chronic pain. Treating both the pain and the depression in separate groups found a reduction in pain to cause a greater reduction in depression than the reduction in depression has on pain reduction. Clearly, even as pain appears to have a greater effect on depression they both act on each other, indicating the causal relationship is bi-directional. These studies imply three explanations of the relationship between personality and pain: that pain causes depression (Gambassi, 2009; Romão et al., 2009), that depression causes pain (Klauenberg et al, 2008; Schieir, 2009) and that both relationships exist bi-directionally (Adkins & Scott, 1996). It is clear that as a wealth of evidence exists supports both depression is caused and causes pain that a bi-directional relationship is a plausible explanation.

Personality's relationship with pain is not exclusive to hysteria and depression. Harm avoidant personalities (Stewart, Ebmaier & Deary, 2004) have been found to display a heightened response to pain (Pud, Eisenberg, Sprecher, Rogowski & Yarnitsky, 2004) and intriguingly an improved responsiveness to morphine (Pud et al., 2006). The increased responsiveness to morphine may not be directly due to personality, but the pain sensitivity associated with the personality. As the harm avoidant personalities are hypersensitive to pain the analgesic effect of morphine is expected to be greater. Harm avoidant personalities share many characteristics with neurotic personalities (Stewart et al., 2004). Paine, Kishor, Worthen, Gregory & Aziz (2009) and Paine, Worthen, Gregory, Thompson, & Aziz (2009) found neurotic participants to have a very low visceral pain tolerance. Interestingly they also found extraverted participants to have a high visceral pain tolerance. This can, at least in part, be explained by Ramírez-Maestre, Martínez & Zarazaga (2004) who attributed successful pain coping mechanisms to extraverts and less successful pain coping methods to neurotics. Alongside hysteria and depression 'Type D'

personalities are also common in chronic pain patients. A type D personality was originally suggested by Denollet et al. (1996) as a predictor of heart disease and is characterised by negative affectivity and social inhibition. Barnett, Ledoux, Garcini & Baker (2009) found 42.5% of chronic pain patients to possess a Type D personality. This finding is strikingly larger than the prevalence of 28% in the general population possessing a Type D personality (Denollet, 2005). The bulk of this evidence indicates that hypochondriasis, hysteria, depression, neuroticism and 'Type D' personalities are related to pain sensitivity. All of these personality traits consist of negative mood and frequent anxiety, two transient states that induce pain sensitivity.

An important review of the relationship between personality and pain by Vendrig (2000) states that psychological problems can mediate chronic pain, but not acute pain. This is certainly contrary to any study establishing a relationship between experimental pain and personality (Klaunberg et al., 2008; Paine et al., 2009; Pud et al., 2006) or even transient states such as anxiety or mood (De Wied & Verbaten, 2001; Kirwilliam & Derbyshire, 2008; Weisenberg, Raz & Hener, 1998). The majority of evidence suggests that personality can mediate acute pain to an extent (Klaunberg et al., 2008; Paine et al., 2009; Pud et al., 2006), but this dispute in research indicates caution in generalisation between chronic and acute pain findings. Further evidence suggests that personality can mediate acute pain to the extent that it develops into a chronic pain condition (Pincus, Burton, Vogel & Field, 2002; Linton, 2000, Greenberg, Nicassio, Harpin & Hubbard, 2008). These findings importantly aid our knowledge of the interaction of personality and pain and also why these interactions may vary between acute and chronic pain conditions. Depressive traits appear to be a clear contributor to the development of an acute pain condition becoming chronic. Pincus et al. (2002) conducted a comprehensive review of studies investigating the transition from acute to chronic pain. This review concluded that depression, distress and somatisation are the key psychological factors of chronic pain development. These findings are also supported by Linton (2000) who found depressive traits to be a crucial factor in the transition

between acute and chronic pain. Casey et al. (2008) attributed psychological factors as a greater cause of acute pain developing into chronic pain than the medical condition itself, stating stress, anxiety and depression to be the key psychological factors responsible for the development of chronic pain. Fear and associated transient states such as anxiety can also be attributed to the development of chronic pain (Klenerman et al., 1995). Williams et al. (1998) found job dissatisfaction to be a predictor of chronic pain development, with occupationally dissatisfied acute pain patients more likely to develop chronic pain. There are two clear explanations for this finding. Williams et al. attributed this result to the depression related to the dissatisfaction. An alternative explanation is that dissatisfied acute pain patients have a greater motivation to display a 'sick role' behaviour as it enables them to have an excuse to avoid work. It is hard to pull apart which explanation is valid, or whether both are moderately responsible for this finding. This collection of evidence highlights that the medical symptoms themselves are not fully responsible for the development of chronic pain. Depressive traits and somatisation alongside situational variables appear even more responsible for this progression than the medical condition (Casey et al., 2008).

Pain catastrophising is a trigger for the development of acute to chronic pain (Lipton, 2000). Pain catastrophising is a persistent negative exaggerated orientation of noxious stimuli (Sullivan, Bishop & Pivik, 1995) that is not only attributed to the development of chronic pain but as an exacerbator of acute pain (Swinkels-Meewisse, Roelofs, Oostendorp, Verbeek & Vlaeyen, 2006). In relation to personality and pain, catastrophising can be considered a behaviour that is displayed by some individuals due to their personality. Various studies identify a link between personality and pain catastrophising (Figure 4). It is hard to determine how Lackner et al.'s and Goubert et al.'s findings interact as the reported pain sensitivity can originate from depressive traits, neuroticism or the catastrophising itself. It is plausible that traits such as neuroticism and depression are likely to lead an individual to display catastrophising behaviour. This behaviour

leads to a heightened sensory perception and decreased attention control (Muris et al., 2007).

These cognitive effects are likely to be responsible for the pain sensitivity. This relationship provides explanation of how catastrophising leads to chronic pain, as its associated traits also lead to chronic pain.

Author(s)	Year	Findings
Lackner, Quigley & Blanchard	2004	Depression leads individuals to catastrophise. This subsequent catastrophising leads to pain sensitivity.
Goubert, Crombez & Van Damme	2004	Neuroticism lowers pain threshold and the level pain is perceived as threatening. This increased level of perceived threat leads an individual to catastrophise over pain.
Sinclair	2001	Constructed a predictive model derived from the Pain Catastrophising Scale (Sullivan, Bishop & Pivik, 1995) that explained 61% of variance on the scale. Sinclair found catastrophisers to display pessimism and helplessness and utilised venting and passive coping methods in an attempt to alleviate their pain.
Ellis & D'Eon	2009	Fifty percent of persistent catastrophisers of head pain didn't catastrophise in the experimental mechanical finger pain task. This indicates that catastrophising is strongly affected by situation and any replication of catastrophising in an experimental setting should be treated with caution. This discrepancy is possibly due to participants knowledge that experimental pain is short lived, whilst headache lasts an indefinite amount of time. Additionally, headache can be perceived as threatening to your body whereas the participant trusts experimental pain not to leave long-term effects.
Ellis & D'Eon	2009	Published in the same article, Ellis and D'Eon found catastrophising is related to levels of fear, disgust, anger and hostility.

Figure 4: Personality traits such as depression and neuroticism lead to catastrophising. Catastrophising may also be specific to situation or perceived threat.

The problem with pain

The study of personality is hazardous as personality itself defines how we report our personalities. Pérez-Pareja, Sesé, González-Ordi & Palmer (2010) encountered this issue studying

fibromyalgia patients who were compared with healthy controls using the MMPI. Fibromyalgia patients possessed greater levels of hysteria, depression, hypochondriasis, psychopathic deviate, paranoia, psychasthenia and schizophrenia than healthy controls. It is very likely this is an example of over reporting and attention seeking behaviour rather than fibromyalgia patients actually presenting high levels of all of these traits. Greater caution is therefore required when reporting anomalous results.

The majority of research in this field has usually involved patients suffering from a medical condition rather than healthy individuals. Unfortunately medical symptoms vary considerably across patients. Personality research using patients is therefore limited by the confound of symptom variation; it is problematic to decide whether any findings are due to personality, or the medical condition itself. Bru, Reidar & Svebak (1993), for example, found neuroticism correlated strongly with reports of neck and shoulder pain, but not with back pain. This is an intriguing finding, but without knowledge of how pain and neuroticism interact, independent of medical conditions, it is hard to fully interpret the result. Studying healthy participants with controlled noxious stimuli rather than bodily symptoms is one way to avoid this confound.

The study of experimental pain in healthy participants preserves objectivity in a replicable environment, free of confounding variables. Sadly whilst such research is generalisable it initially has little relevance or benefit for the individuals that need it the most, chronic pain patients. The confound of symptom variation and over-specific medical investigation render a large amount of clinical research to certain medical conditions rather than the general population. There are only two approaches that research can follow to overcome this predicament, replicating over-specific findings in the general population or establishing findings in the general population and generalising them to specific medical conditions. Firstly, studies with findings that benefit a specific medical condition should be replicated with groups suffering from other medical

conditions. This allows us to study which findings generalise across condition and why. In the case of personality this will highlight whether personality specifically relates to pain or the condition itself. Secondly, research would investigate experimental pain sensitivity and personality in a healthy population. This would highlight the specific relationship between personality and pain with no symptom confound. This research could progress, replicating the experiment across medical conditions and varying types of pain. This approach is slow to benefit chronic pain patients, but provides an objective personality model, free of symptom confound. Therefore this approach would produce a stronger theoretical backing, which in the long-term is likely to lead to a greater benefit for those who need it.

An important review, published in *Pain*, (Tillisch, 2009) has identified a series of other problems relating to personality and pain research. These problems include overcomplicated experimental methods, un-standardised measurements and over-specific populations. Consequently the findings from personality pain research are heterogeneous and no clear personality phenotypes have yet been identified as having a specific influence on pain report. The individual studies tend to be far too specific and cannot be easily generalised. Tillisch recommends that future studies involve standardised procedures, measurements and environment. Specifically, this means using the same extensive battery of questionnaires to assess the influence of personality traits on pain report during delivery of a standard lab based noxious stimulus. Modern innovations have identified optimum methods of pain induction such as the Contact Heat-Evoked Potential Stimulator (CHEPS) (Chen et al., 2006). CHEPS can be used to establish pain tolerance and threshold using standard psychophysical procedures, such as the staircase method (Willer, 1977), as well as investigating other noxious sensory phenomena such as signal detection (Kirwilliam & Derbyshire, 2009) and the recently developed offset analgesia (Derbyshire & Osborn, 2008; 2009). In addition, large participant samples are a necessity with

careful consideration and control of sex, age and environmental differences. Personality and pain research will then not be limited to specific traits or medical conditions.

The significant traits

Anxiety and mood are two triggers of pain sensitivity and as these states are frequently present in personality traits such as hysteria, depression, hypochondriasis and paranoia it is highly likely that individuals with these traits suffer from innate pain sensitivity. Villalpando et al. (2005) reported fibromyalgia patients to possess levels of hysteria, depression and anxiety significantly greater than healthy controls. Depression is possibly more prevalent in fibromyalgia patients due to the detrimental effect the condition has on their lives and therefore may be a consequence rather than a cause of pain. Hypochondriasis, in some cases, may also be a consequence rather than trigger of fibromyalgia. Personality tests identify hypochondriasis as an increasingly irrational anxiety of personal bodily safety and identify this through questions relating to bodily functions and memories of unfortunate medical events (Dahlstrom & Welsh, 1962). Due to the debilitating nature of fibromyalgia, participants completing personality inventories such as the MMPI are more likely to recall medical events and abnormal bodily function, as they are in fact more frequent in this condition, rendering the participant a hypochondriac under MMPI criteria, even when they are not irrationally anxious over their condition. The findings relating to hysteria, however, are more likely to be valid.

Traditionally tests for hysteria, such as the original MMPI identify participants who use physical symptoms to avoid or distract from personal conflicts, responsibilities or stress (Dahlstrom & Welsh, 1962). Recently, hysteria is considered a component of Somatisation Disorder, in which patients report physical symptoms which remain unexplained by medicine, and consequently must be caused by mental state (World Health Organisation, 1992). Revisions of the MMPI have transformed the once "Hysteria Scale" to "Scale 3". Scale 3 now concentrates on the emotional awareness of an individual's own failings and vulnerabilities (Tellegen et al., 2003)

rather than the traditional components of hysteria. As this revised scale fails to test for hysteria, it consequently is an inadequate test for Somatisation Disorder. Watson & Tilleskjoer (1983) suggests that current definition of Somatisation Disorder (hysteria) concentrates on patient's psychological difficulties manifesting as physical symptoms which is limited as it fails to include psychalgia (a physical pain that is caused by mental or emotional factors rather than noxious stimulation). To allow for this, ICD-10 detailed Persistent Somatoform Pain Disorder (PSPD), a condition matching the symptoms of Somatisation Disorder but also with patients presenting psychalgia (World Health Organisation, 1992). Intriguingly PSPD shares pain abnormalities with fibromyalgia (Arnold et al., 2008; Karst et al., 2005), with both conditions displaying pain sensitivity related to patients mental state. As both Fibromyalgia and PSPD are related to high levels of hysteria and can be classified as pain sensitivity disorders it is highly likely hysteric individuals will also possess this sensitivity to pain.

Hypothesis

This paper hypothesises that participants with low thresholds and tolerances to thermal pain will have high MMPI scores for hysteria, depression and hypochondriasis. As research indicates a connection between personality and pain sensitivity we suggest that there will also be a significant relationship between thermal pain sensitivity (threshold and tolerance) and psychopathic deviate, gender inversion, psychasthenia, paranoia, schizophrenia, hypomania and social participation. As chronic pain patients encounter greater pain and greater sensations during anomalous sensory experiences this paper hypothesis that participants with low thresholds and tolerances to thermal pain will experience greater anomalous sensations and ownership during the rubber arm illusion.

Method

Participants

49 participants (40 female, 9 male; mean age = 20.8yrs) were all fluent in English and were sampled through the University research participation scheme. This amount of participants is characteristic of current personality and experimental pain research (Klauenberg et al., 2008; Paine et al., 2009; Pud et al., 2006). This participation scheme requires undergraduate psychology students to complete 30 hours of research participation in order to pass their academic year. All participants provided written informed consent and the study was approved by the University of Birmingham Ethics Committee.

Materials

Heat stimulation was delivered via a 27mm circular thermode using the Contact Heat Evoked Potential Stimulator (CHEPS). CHEPS allows precisely timed delivery of heat controlled by a computer using Pathway software. Cold stimulation was delivered using a cold pressor maintaining water at a constant 3.9°C temperature.

Personality was measured with the Hathaway & McKinley's (1951) Minnesota Multiphasic Personality Inventory (MMPI). This measure consists of ten clinical subscales identifying tendencies towards hypochondriasis, hysteria, depression, psychopathic deviate, gender inversion, paranoia, psychasthenia, schizophrenia, hypomania and sociability. This was completed on a Windows XP driven PC with participants required to identify whether they agreed or disagreed with each of 566 statements. The MMPI also produces results for two validity scales (the K and F scales). The K scale tests for evasiveness at the time of completing the test and the F scale tests for participant's exaggeration of the negative severity of their personality. The findings of these two scales are used to validate the ten clinical subscales and to control for evasiveness and negative exaggeration. All findings presented have been validated using this method.

Perceptual abnormalities were measured using the Cardiff Anomalous Perception Scale (CAPS). This scale establishes the variety, frequency, intrusiveness and distress of participants' abnormal perceptual experiences. Participants are presented with 32 perceptual anomalies and asked which they have experienced. The total number of experienced anomalies comprises their variety score (out of 32). For the items which participants have experienced they are asked to rate out of 5 on a Likert Scale the extent to which the anomalies were frequent, intrusive and distressing. These ratings comprise their frequency, intrusiveness and distress scores (each out of 160). Reliability of this measure is strong, with a Cronbach's alpha coefficient of 0.87 for internal reliability and 0.92 for test-retest reliability over 6 months (Bell, Halligan & Ellis, 2006). Validity of this measure is also strong with significant construct validity with 3 established measures (PDI-21, O-LIFE and RLSHS).

Sensitivity to the rubber hand illusion was measured with Botvinick and Cohen's (Botvinick & Cohen, 1998) 7 item questionnaire to establish feelings of ownership and agency towards the rubber hand. A questionnaire devised from the qualitative findings of McCabe et al. (2005) was also completed to establish sensations participants felt whilst their hand was being stroked. This questionnaire (Appendix C) consists of 9 items requesting participants to rate the degree of pain, discomfort, temperature, weight, and peculiarity of the sensation felt in their hand. This questionnaire also requires participants to rate whether they felt they had lost or gained a hand. All of these factors were identified by McCabe et al. as possible consequences of a sensory-motor conflict. Both of these questionnaires have been devised based upon the findings of Botvinick & Cohen (1998) and McCabe (2005). Neither of which have been tested for reliability or validity. Both of these questionnaires use a 7 point Likert Scale (-3 to 3) with ratings of 2 or 3 indicating strong or very strong agreement with a preceding statement (for example, "I felt pain").

Design

A bivariate correlational design was used to identify relationships between the ten MMPI subscales and heat pain threshold, heat pain tolerance, heat pain sensitivity, heat pain response bias, mean cold pain ratings, rubber hand illusion sensation, CAPS overall score, CAPS frequency score, CAPS intrusiveness score and CAPS distress score.

Participants completed the following six tasks in a single session at various times of the day (between the hours of 9am and 7pm). All sessions took place in the same quiet room and lasted 90 minutes. All tasks were counter-balanced.

Procedure

Test of sensitivity to heat pain

Participants were seated with a circular heat thermode attached to their dominant forearm. This thermode was attached to CHEPS and controlled by Pathway software. Heat stimulation was gradually increased from 35°C using the staircase paradigm (Willer, 1977). Participants were asked to identify the moment of first pain (pain threshold) and then the moment they found it intolerable (pain tolerance).

Test of sensitivity to heat pain detection (Signal Detection Task)

Participants were presented with five 49°C heat pulses and five 40°C heat pulses from a baseline of 35°C using CHEPS. The ISI was five seconds but half the pulses were null events, i.e., no pulse was delivered. Participants were asked every five seconds to identify whether the pulse was painful, hot or absent. All pulses and stimulus absent trials were presented randomly, determined by Pathway software. Comparing participants correct identification of noxious heat (hits), correct elimination of non-painful stimulation (correct rejection), perceived pain without noxious stimulation (false alarm) and noxious stimulation without perceived pain (miss) allows calculation of sensitivity and response bias to heat pain (Kirwilliam & Derbyshire, 2008).

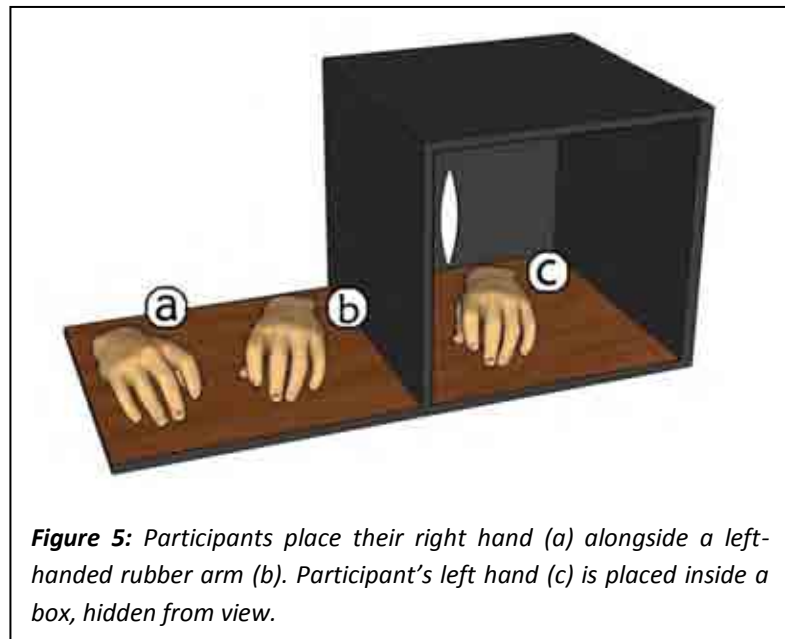
Test of sensitivity to cold pain

Participants were asked to place their dominant hand and wrist in a cold pressor water bath for one minute. They were then asked to rate the severity of their pain out of 20 (0 being no pain, 20 being the most pain imaginable) every 15 seconds. Participant's sensitivity to cold pain was calculated as the mean of the 4 pain ratings.

Test of sensitivity to the rubber hand illusion

Participants placed their hands either side of a fake left hand with their left hand hidden from view (see Figure 5). Participants were informed that both their left hand and the fake hand

would be stroked for one minute. Participants were asked to concentrate on the rubber hand and any sensations that they felt. The test was conducted in silence and no indication was given to participants of how the illusion traditionally presents



itself. After the hands were stroked in synchrony for one minute participants were presented with two questionnaires to assess the strength of the rubber hand illusion (Botvinick & Cohen, 1998; McCabe et al., 2005). Both of these questionnaires use a 7 point Likert Scale (-3 to 3) with ratings of 2 or 3 indicating strong or very strong agreement with a preceding statement (for example, "I felt pain"). As all tasks were counter balanced if this task immediately followed the cold pressor task participants were given a short break until the numbness and redness had left their dominant hand to ensure participants could fully feel the stroking. This consideration was implemented to ensure any negative effects from the cold pressor task didn't detract from the strength of the illusion and its associated sensations.

Tests of personality and perceptual abnormalities

Participants completed the MMPI on a PC and the CAPS on paper. Participants were required to respond to every question and complete both questionnaires in silence.

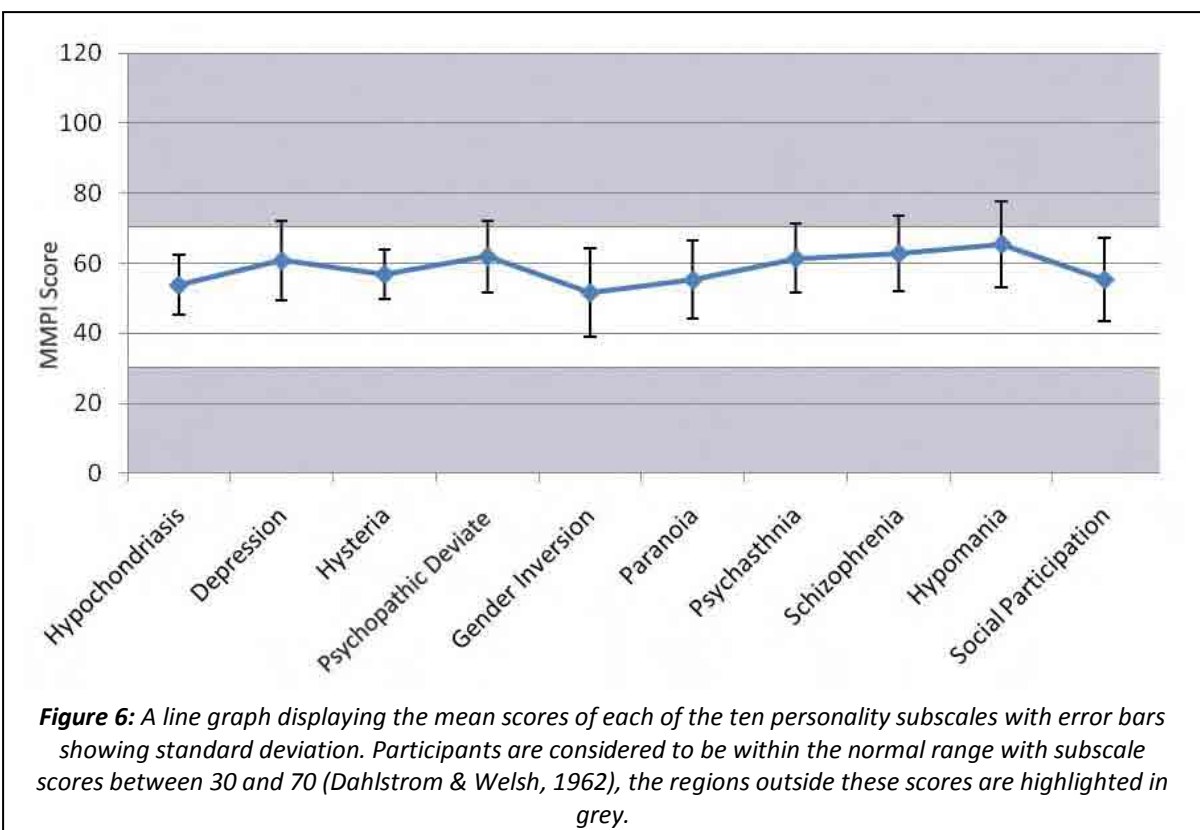
Results

Descriptive Statistics

All participants completed the MMPI; the mean score for each clinical scale is shown in Table 1 and illustrated in Figure 6. Participants scored consistently lower on the gender inversion scale (51.71) and schizophrenia (62.78) than other subscales. Participants scored higher than other subscales in hypomania (65.39).

Hypochondriasis	Depression	Hysteria	Psycho Deviate	Gender Inversion
53.86 (8.71)	60.73 (11.41)	56.88 (7.02)	61.86 (10.13)	51.71 (12.72)
Paranoia	Psychasthenia	Schizophrenia	Hypomania	Social Participation
55.33 (11.05)	61.37 (9.87)	62.78 (10.75)	65.39 (12.16)	55.39 (11.97)

Table 1: Mean subscale scores with standard deviation shown in brackets (n=49, minimum score = 0, maximum score = 120, typical range = 30-70). Higher scores indicate greater possession of the trait.



A considerable amount of variance was observed in the Cardiff Anomalous Perception Scale scores (means and SD's shown in Table 2) with participants scoring either low or relatively high (range = 0 to 74). Means and standard deviations for the remaining measures are also shown in Table 2.

Rubber Arm	CHEPS				Cold Pressor Pain Intensity Rating
	Pain Threshold		Pain Tolerance		
2.39 (1.97)	42.51 (2.17)	45.55 (2.16)		12.04 (4.61)	

CAPS			
Responses	Distress	Distraction	Frequency
6.67 (5.08)	13.59 (13.56)	17.12 (17.43)	12.98 (14.39)
<i>7.3 (5.8)</i>	<i>15.5 (14.5)</i>	<i>18.0 (17.0)</i>	<i>14.6 (14.2)</i>

Table 2: (n=49). Mean scores for sensitivity to the rubber hand illusion (out of 48), mean heat pain threshold and heat pain tolerance testing using CHEPS, mean cold pressor pain intensity rating (out of 20), and mean ratings for CAPS scales (all out of 160 other than for responses, which is out of 32). Standard deviation is shown in brackets. The mean ratings and standard deviations of 337 participants sampled from the general population by Bell, Halligan & Ellis (2006) are shown in italics.

Correlations

The hypochondriasis, depression, gender inversion, paranoia, psychasthenia and social participation scales were all found to have non-normal distributions. All remaining personality subscales fulfilled parametric criteria. The normality of the distributions was tested using the Shapiro-Wilks test.

Spearman's rank correlation coefficient failed to find a significant relationship ($p < 0.05$) between pain sensitivity (mean cold pressor ratings, CHEPS heat pain tolerance or CHEPS heat pain threshold) and hypochondriasis or depression. Pearson's correlation coefficient identified a significant negative relationship between hysteria and CHEPS heat pain threshold ($r = -0.262$, $p = 0.034$). This relationship is illustrated in Figure 7. A positive correlation between gender inversion and CHEPS heat pain threshold trended close to significance ($r = 0.279$, $p = 0.052$). There

Personality Trait	Cold Pressor ¹		Heat Pain Threshold		Heat Pain Threshold	
	Correlation	Sig. (1-tailed)	Correlation	Sig. (1-tailed)	Correlation	Sig. (1-tailed)
Hypochondriasis ¹	-.092	.266	-.033	.411	-.120	.206
Depression ¹	-.022	.441	-.011	.469	.031	.417
Hysteria	.011	.471	-.262	.034 ²	-.224	.061

Personality Trait	Cold Pressor ¹		Heat Pain Threshold		Heat Pain Threshold	
	Correlation	Sig. (2-tailed)	Correlation	Sig. (2-tailed)	Correlation	Sig. (2-tailed)
Psychopathic Deviate	-.168	.25	.109	.454	.066	.65
Masculinity-Femininity ¹	.012	.934	.279	.052	.201	.167
Paranoia ¹	-.144	.324	-.035	.812	-.026	.857
Psychasthenia ¹	-.123	.4	-.144	.323	-.051	.728
Schizophrenia	-.102	.488	.175	.230	.184	.206
Hypomania	-.019	.898	.155	.288	.012	.933
Social Participation ¹	-.156	.283	-.045	.758	-.058	.693

Table 3: Results of correlation coefficient tests between MMPI subscales and tests of pain sensitivity. Only Hysteria subscale scores and heat pain threshold are found to be negatively correlated ($n=49, p=0.34$).

¹ - Spearman's rank correlation coefficient test used

² - significant at 0.05 level

Pearson's correlation coefficient test used unless otherwise stated

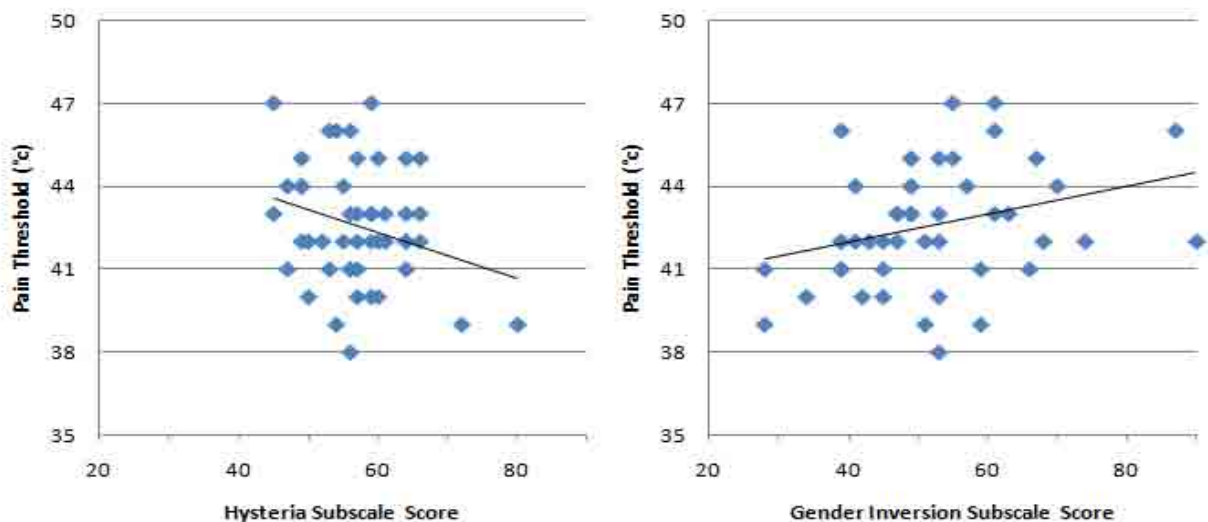


Figure 7: A scatter graph illustrating the negative correlation (-.262) between hysteria and heat pain threshold (left) and the positive correlation (.279) between gender inversion and heat pain threshold (right) ($n=49$).

was also a negative, but just below significant, correlation between hysteria and CHEPS heat pain tolerance ($r=-0.224$, $p=0.061$). No further significant or close to significant correlations were identified. All the correlations are shown in Table 3. Post-hoc Spearman's correlation coefficients found no relationship between the rate of change in cold pressor pain ratings and MMPI subscales.

Signal Detection Task

Participant's individual pain sensitivity (d') and response bias (c) were calculated (hits misses and false alarms are shown in table 4) and correlated with their MMPI scores. No significant relationships were found (see table 5).

	Pain Hit	Heat Hit	Correct Rejection	Miss	False Pain	False Heat
Frequency	169	169	214	75	1	107
Occurrence	68.98%	68.98%	87.35%	15.31%	0.20%	21.84%

Table 4: Participants correctly identified pain (Pain Hit) and heat (Heat Hit) in 68.98% of trials. Participants were consistently more accurate (87.35%) at identifying the absence of heat stimulation (Correct Rejection). Participants rarely perceived pain in the absence of noxious stimulation (False Pain) or failed to perceive pain in the presence of noxious stimulation (Miss) ($n=49$).

Relationships between measures

Significant correlations were observed between the sum of perceptual abnormalities participants recalled experiencing and CHEPS heat pain threshold ($r=-0.291$, $p=0.043$), CHEPS heat pain tolerance ($r=-0.325$, $p=0.023$) and rubber arm illusion sensitivity ($r=0.295$, $p=0.040$). Significant negative correlations were also observed between the intrusiveness of the perceptual abnormality and CHEPS heat pain threshold ($r=-0.293$, $p=0.041$) and CHEPS heat pain tolerance ($r=-0.299$, $p=0.037$). A significant negative correlation was found between the frequency of perceptual abnormalities and CHEPS heat pain threshold ($r=-0.290$, $p=0.044$). A significant

Personality Trait	d' (Pain Sensitivity)		c (response bias)	
	Correlation	Sig. (1-tailed)	Correlation	Sig. (1-tailed)
Hypochondriasis ¹	-.053	.359	-.015	.460
Depression ¹	-.007	.481	-.052	.361
Hysteria	.051	.364	-.070	.316

Personality Trait	d' (Pain Sensitivity)		c (response bias)	
	Correlation	Sig. (2-tailed)	Correlation	Sig. (2-tailed)
Psychopathic Deviate	-.036	.807	.045	.758
Masculinity-Femininity ¹	-.108	.459	.084	.567
Paranoia ¹	.158	.28	-.132	.366
Psychasthenia ¹	.03	.84	-.071	.629
Schizophrenia	.033	.820	-.007	.964
Hypomania	.089	.543	-.113	.44
Social Participation ¹	-.2	.168	.17	.243

¹ - Spearman's rank correlation coefficient test used
 Pearson's correlation coefficient test used unless otherwise stated

Table 6: Results of correlation coefficient tests between MMPI subscales and Signal Detection sensitivity (d') and response bias (c) (n=49).

	Cold Pressor Rating		Heat Pain Threshold		Heat Pain Tolerance		Rubber Arm Score	
	Correlation	Sig.	Correlation	Sig.	Correlation	Sig.	Correlation	Sig.
CAPS responses	.013	.927	-.291	.043*	-.325	.023*	.295	.04*
CAPS distress	-.050	.733	-.248	.086	-.274	.057	.235	.104
CAPS distraction	-.033	.822	-.293	.041*	-.299	.037*	.228	.115
CAPS frequency	-.142	.332	-.290	.044*	-.253	.079	.148	.309
Rubber Arm Score	-.114	.434	-.203	.161	-.306	.032*		

Table 6: Results of Spearman's Rank Correlation Coefficient between CAPS, Rubber hand illusion sensitivity and heat pain sensitivity (n=49).

* - significant at 0.05 level (2-tailed)
 Spearman's rank correlation coefficient test used

negative correlation was also observed between rubber hand illusion sensitivity and heat pain tolerance (r=-0.306, p=0.032). The findings of all correlations are shown in Table 6.

Participants were not found to be sensitive to both heat and cold pain. No significant correlations were observed between mean cold pressor ratings and heat pain threshold ($r=-.046$, $p=0.377$) or heat pain tolerance ($r=-0.220$, $p=0.065$). Predictably, there was a strong positive correlation between heat pain threshold and heat pain tolerance ($r=0.609$, $p<0.001$).

Factor Analysis

Due to the wide range of the MMPI's ten clinical scales Factor Analysis was conducted to group the scales to four relatively exclusive factors. The first factor comprised predominantly of

	Gender Inversion	Self Pity	Hostility	Social Introversion
Depression				.861
Social Participation				.856
Psychasthenia				.804
Schizophrenia				.626
Paranoia			.509	.538
Psychopathic Deviate				.510
Hysteria		.907		
Hypochondriasis		.885		
Hypomania			.936	
Gender Inversion	.923			

Table 7: Factor Analysis has identified four relatively exclusive factors (Gender Inversion, Self Pity, Hostility and Social Introversion). All are exclusive other than Hostility and Social Introversion which both possess aspects of the Paranoia subscale. The figures show the weightings of each personality subscale on each factor.

the gender inversion scale and consequently this factor was named gender inversion. The second factor comprised of the hysteria and hypochondriasis scales was named self pity and the third factor comprised of the hypomania and paranoia scales was named hostility. The self pity and hostility factors were identified by Dahlstrom & Welsh (1962) as common combinations observed in samples. The fourth factor comprised of depression, social participation, psychasthenia, schizophrenia, paranoia and psychopathic deviate. Dahlstrom & Welsh (1962) reports combinations of the three most prevalent traits in this factor, depression, social participation and

psychasthenia, to culminate as social introversion. Therefore the fourth factor, at least in part, can be identified as social introversion. The breakdown of individual factors with their weightings are shown below in Table 7.

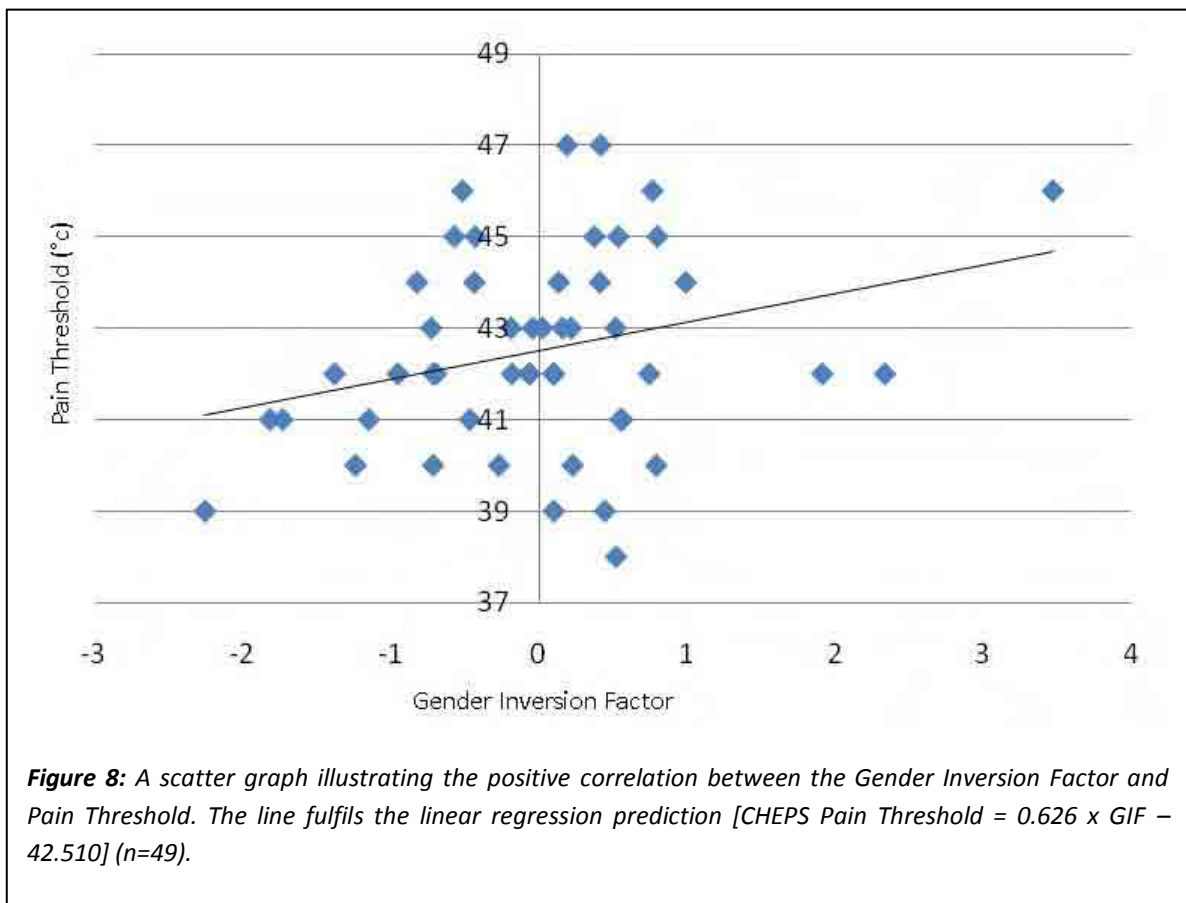
Linear Regression

Linear regression analysis of the Gender Inversion factor (GIF) and Gender Inversion scale (GI) predicted:

$$\text{CHEPS Pain Threshold} = 0.626 \times \text{GIF} - 42.510 \quad (r^2=0.083, \text{df}= 47, p=0.044)$$

$$\text{CHEPS Pain Threshold} = 0.047 \times \text{GI} - 40.081 \quad (r^2=0.076, \text{df}=47, p=0.055)$$

All further linear regression analysis of the 10 clinical scales and 4 factors failed to show a significant prediction of pain threshold, pain tolerance or cold pain ratings. Linear regression analysis of the Hysteria scale found a mild, but insignificant prediction:



$$\text{CHEPS Pain Threshold} = -0.081 \times \text{Hysteria} - 47.130 \quad (r^2=0.069, \text{df}=47, p=0.068)$$

The only significant prediction is between CHEPS Pain Threshold and GIF (shown above) ($r^2=0.083$, $\text{df}= 47$, $p=0.044$). This model is illustrated in Figure 8.

Discussion

Interpretation of the Results

The results of this investigation indicate that reduced pain threshold and high levels of hysteria are related. This investigation also found a curious relationship between gender inversion and pain threshold. Correlational analysis found individuals with high levels of gender inversion possess a higher pain threshold. Originally this relationship, whilst being a moderate correlation, was insignificant. After factor analysis the gender inversion scale was subtly adjusted to have greater exclusivity from the other nine scales. Further correlational analysis of this new 'Gender Inversion Factor' and linear regression not only found a significant positive relationship between gender inversion and pain threshold, but also a predictive model. Finally, a negative relationship was observed in which participants with a lower pain tolerance encountered a stronger rubber hand illusion.

The negative relationship between pain threshold and hysteria is supported, in part by Villalpando et al. (2005) which noted a relationship between hysteria and the functional pain disorder fibromyalgia. A similar investigation found hysteria to be more prevalent in Non-Specific Low Back Pain (NSLBP) patients than healthy controls (Prokop, 1986). The limitation of Prokop's and Villalpando et al.'s investigations is that no direction can be inferred from the relationship. Hysteria, as defined for the purposes of the MMPI is now considered a component of Somatisation Disorder and consequently a component of the subsidiary disorder Persistent Somatoform Pain Disorder (PSPD) (World Health Organisation, 1992). PSPD is a somatisation disorder characterised by chronic pain sensitivity and functional pain. The reduced pain tolerance and increased hysteria observed in this investigation is characteristic of people with PSPD. Further investigation is required to establish this link between hysteria, acute pain and the development of chronic pain symptoms.

There is little research in the field of gender inversion or homosexuality and pain sensitivity. It is frequently reported that women have greater pain sensitivity than men (Jones &

Zachariae, 2002) but these experiments only control for biological sex rather than gender. A higher score on the gender inversion scale indicates that the participant has preferences that are more traditionally held by a member of the opposite sex, rather than being specifically masculine or feminine. The MMPI would suggest that these individuals are homosexual (Dahlstrom & Welsh, 1962). This conclusion has been frequently contested due to high misclassification levels (39%; Cubitt & Gendreau, 1972). The removal of a homosexual interpretation in this scale indicates high scores to be passive, intelligent and possess preferences of the opposite gender (Hathaway & McKinley, 1989). Whilst this may appear to be a collection of sub-traits factor analysis suggests this trait to be significantly homogenous. High scores on this scale have also been indicative of greater intelligence (Dahlstrom & Welsh, 1962). It can be suggested from the strength of these results that individuals who are intelligent and possess opposing gender preferences have a heightened pain threshold.

The most intriguing, and unexpected finding of this investigation were those related to the experimental measures themselves. Individuals who recall experiencing more varied, more frequent or more distracting perceptual abnormalities have greater sensitivity to pain (threshold and tolerance) and are also more likely to experience the rubber hand illusion. The rubber hand illusion can be considered as a perceptual abnormality, so a correlation between the two simply emphasises the reliability of the two measures. The intriguing finding, that greater perceptual anomalies are related to greater pain sensitivity is observed, in part by Blakemore, Oakley & Frith (2003). Blakemore et al. (2003) reported a greater sensory experience during an unplanned motor action than during a planned motor action. Therefore a perceptual abnormality could lead to a greater sensory experience, possibly leading to pain. Blakemore et al. (2003) only observed this sensitivity whilst the perceptual abnormality was taking place, but the participants in this current investigation were, to our knowledge, not encountering any abnormalities whilst being subjected to pain.

Limitations of the Results

The MMPI used for this investigation was produced in 1951 and is consequently 59 years old. Whilst personality traits can be considered stable over this period the cultural context that the MMPI uses for diagnosis has evolved. A clear example is depression, which as a trait can be considered unchanged over the last 60 years, but the MMPI features a question testing for depression that is no longer culturally relevant. If a participant believes that the statement “Everything is turning out just like the prophets of the Bible (or relevant religious text) said it would” is false they are considered to be depressed. That may have been correct in the 1950s but in our modern more secular age, this question fails to validly test for depression. The example is extreme, there are 59 other potentially valid questions testing for depression, but in the case of the gender inversion scale the problem is more significant. The gender inversion scale of the MMPI considers preferences for poetry, books, journalism the theatre and to be feminine traits. These preferences may have been characteristic of women in the 1940’s and 1950’s but liberalism and modernisation of the last 60 years has led to these statements losing their validity. Revisions of the MMPI have been produced to allow for this cultural and social evolution, and replication of this experiment with this new measure would produce more valid results. These revised MMPI’s would validly evaluate gender inversion in a 21st century context and implementation of these tests would benefit research in this area. This may not be the case for all personality traits. The newer versions of the MMPI have replaced the hysteria scale, so replication of the relationship between hysteria and pain threshold would not be possible. Currently tests for hysteria (Somatisation Disorder) are completed by repeated visits to physicians, developing a case history rather than through scientific testing. Therefore the original MMPI remains an obvious choice for experimental testing of hysteria and should be considered for replication.

Predictably there was a strong positive relationship between pain threshold and pain tolerance established with CHEPS. A relationship was not observed between CHEPS pain

sensitivity and that established via the cold pressor. No significant relationships were observed between the cold pressor and any other measures, including the ten MMPI subscales. The cold pressor, as a test of pain sensitivity is inaccurate, particularly in comparison to CHEPS. The cold pressor stimulates more than just nociceptors as it provides a deep cold sensation throughout your hand leading to increased surface blood flow, slower synaptic transmission, and critically, reduced nociception efficiency (Proudfoot et al., 2006). The cold pressor, from a participant's viewpoint, is a very explicit method of pain induction. Participants are asked to place their hand in a bath of very cold bubbling water, an act that they know will produce a noxious consequence. This is not an adequate replication of a typical noxious situation and presents increased levels of anxiety that are unnecessary and potentially confounding. The cold pressor does not control for these confounding variables, which can be controlled through the use of CHEPS, so consequently CHEPS is a more suitable method for pain induction.

Participants completing the signal detection task anecdotally reported that as the trials progressed it was easier to classify the signals as they had experience of the prior signals (and their intensity relative to each other) as a guide. Therefore this practice effect led participants to become much more accurate at detection for the latter half of the task, regardless of whether they felt pain. For replication this confound can be simply countered by presenting a maximum of five trials in a batch.

A further problem was that only 15 trials were used, which limited the power to produce a significant result. Replication of this task would require at least 60 trials per participant. With these two limitations considered at least 12 batches of 5 trials should be presented to participants in order to obtain valid results.

During the rubber hand task participants were not informed of how the illusion traditionally presents itself. Typically a brief description of the illusion is presented during the task and its absence may explain why occurrence of the illusion in this investigation is lesser than that

observed by Botvinick & Cohen (1998). Participants who did experience the illusion in this study did so without priming or expectation and subsequently everything they experienced was induced without these confounds. Further study of how the illusion is presented to participants will highlight the strength of these confounds and also the susceptibility of the participants.

The reporting of the strength of the illusion was also limited by the format of the two questionnaires used. Anecdotally participants frequently reported experiencing the illusion, but whilst completing the questionnaire felt the illusion was not strong enough to rate as a '+2' or '+3' (responses considered as significantly experiencing the illusion). It is possible these questionnaires require modification to allow for participants who experienced the illusion, but at a weaker extent.

Suggestion of Further Research

Due to the small amount of research into homosexuality and pain sensitivity these findings require replication with the current MMPI to establish whether pain sensitivity is related to homosexuality or individuals who possess homosexual characteristics of the 1950's. This can also be investigated by subjecting homosexuals and heterosexuals to pain sensitivity tests and comparing their thresholds and tolerances.

A relationship between perceptual abnormalities and pain sensitivity can provide an insight into the mechanisms behind anomalous perception. Inducing a scenario akin to the rubber hand illusion that provides a sensory and motor incongruence will induce a heightened sensory experience and possibly pain. This finding will illustrate how pain relates to sensory-motor incongruence.

Unfortunately it is tricky to define a causal relationship between pain sensitivity and personality. Only study of participant's personality prior to onset of pain sensitivity would validly define this relationship. This approach is also limited by the huge variance in personality. Large

samples would be required to find participants who are significantly hysterical and periodically ascertaining their pain sensitivity would be time consuming and financially unfeasible. The casual relationship can be explored qualitatively through interviews with fibromyalgia patients, who are characterised by pain sensitivity. Self-reports from fibromyalgia patients of how they perceive their personality has changed from before the onset of the condition until the present will highlight the personality traits that have consistently been present and those which have developed since diagnosis.

Hysteria and Fibromyalgia

Hysteria, as defined in the 1950's presents symptoms similar to Persistent Somatoform Pain Disorder and Fibromyalgia, both of which are characterised by pain sensitivity. A positive relationship between hysteria and pain sensitivity reinforces this similarity and in part may explain why hysteria is co-morbid with fibromyalgia. Cognitive Behavioural Therapy (CBT) is a popular therapeutic intervention of fibromyalgia. CBT is typically used in this case to reduce anxiety, to encourage assertiveness and to promote participation in new activities and experiences (Bennett & Nelson, 2006; Williams, 2003). It is feasible that these practices have indirectly reduced patients' levels of hysteria and consequently alleviated pain. Further research in this field will identify if CBT is altering patient's hysterical personalities and whether alleviating hysterical tendencies may also alleviate the symptoms of fibromyalgia.

Conclusions

The positive relationship between homosexuality and pain resilience is intriguing. It is confounded by the use of a dated personality test, but the traits defined as homosexual in the 1950's do correlate with pain resilience. Replication using modern methods is important to

understand how relevant this result is for homosexuality in the 21st century. Further research of the relationship will define the specific nature of the relationship observed in this investigation.

The most intriguing, and under investigated relationship observed in this relationship is between perceptual anomalies and pain sensitivity. Individuals who encounter more frequent, varied and distracting perceptual anomalies are more sensitive to pain, possibly due to a heightened sensory experience. This fascinating finding and further research can provide a more detailed understanding of the relationship between motor, sensory and nociceptive systems and their interaction with perception.

Chapter Four

Can Sensory-Motor Incongruence Hurt?

Introduction

The Anomalously Perceptive Personality

It is clear that the frequency that an individual experiences perceptual anomalies is consistent over time (Bell, Halligan & Ellis, 2006). As this frequency is consistent and varies between individuals it is logical to presume the existence of a personality that is predisposed to anomalously perceptive experiences. Various personality traits correlate with high levels of perceptual anomalies. Bell et al. (2006) noted that perceptual anomalies are common in schizophrenia and psychosis patients. They continued stating that individuals in the healthy population can possess moderate levels of schizophrenic and psychotic traits and therefore experience moderate levels of perceptual anomalies. An investigation by Larøi, DeFruyt, van Os, Aleman & Van der Linden (2005) found two traits of the NEO Pi-R, neuroticism and openness to experience to strongly correlate with the frequency of hallucinations in the healthy population. Further evidence suggests that high levels of depressive personality (Barret & Etheridge), trait anxiety (Morrison, Wells & Nothard, 2002) and social introversion (Barret & Etheridge, 1994) are associated with hallucinatory experiences. These findings present a plethora of traits that potentially comprise an anomalously perceptive personality. If individuals with this personality are also sensitive to experimental induction of such anomalies this personality can be explored further in an experimental setting. In order to identify whether vulnerabilities to externally and internally generated perceptual anomalies are linked a successful method of inducing externally generated perceptual anomalies is required.

Pain in the absence of injury

The rubber hand illusion is a mechanism that can provide insight into pain. Recent research by Capelari, Uribe & Brasil-Neto (2009) replicated the rubber hand illusion replacing tactile stimuli with tactile-painful stimuli. This replication produced the same illusion, indicating pain perception can be distorted by visual cues. McCabe, Cohen & Blake (2007) reported that

fibromyalgia patients felt pain when performing a hand action visually incongruent to an action observed in a mirror. This pain sensitivity is potentially a greater sensory experience induced by an unplanned motor action, as observed by Blakemore, Oakley & Frith (2003). Blakemore et al. (2003) reported that tactile sensory experience is enhanced during an unplanned motor action than during a planned motor action. This relationship also explains why healthy individuals cannot tickle themselves (Blakemore, Wolpert & Frith, 1998). This observation indicates that the pain sensitivity prevalent in fibromyalgia is linked to altered sensory experience such as that induced by the rubber hand illusion. Clearly as fibromyalgia patients experienced pain in absence of the nociception, nociception is inclusive of this cocktail of sensory input that produces the rubber hand illusion. Fibromyalgia patients suffer from many unexplained pain anomalies and it is vital to discover whether this induced perceived pain is one of these anomalies and whether it occurs to a greater extent or frequency than healthy controls.

There is clear evidence that personality relates to the frequency of perceptual anomalies and that such anomalies may induce pain. An action incongruent to sensation can invoke perceptual anomalies and pain. If a method that includes a sensory-motor incongruence task can successfully induce pain and various perceptual anomalies it can be used as a tool for investigating the relationship between personality and anomalous perception. This investigation aims to identify such a method.

Hypothesis

This paper hypothesises that participants tapping with a finger incongruent to one they see tapping will experience significantly greater anomalous sensation, as tested by the Botvinick & Cohen and McCabe questionnaires, than when what they tap and see is congruent. Specifically this paper hypothesises that participants will report significantly greater pain in the incongruent condition, than the congruent condition.

Method

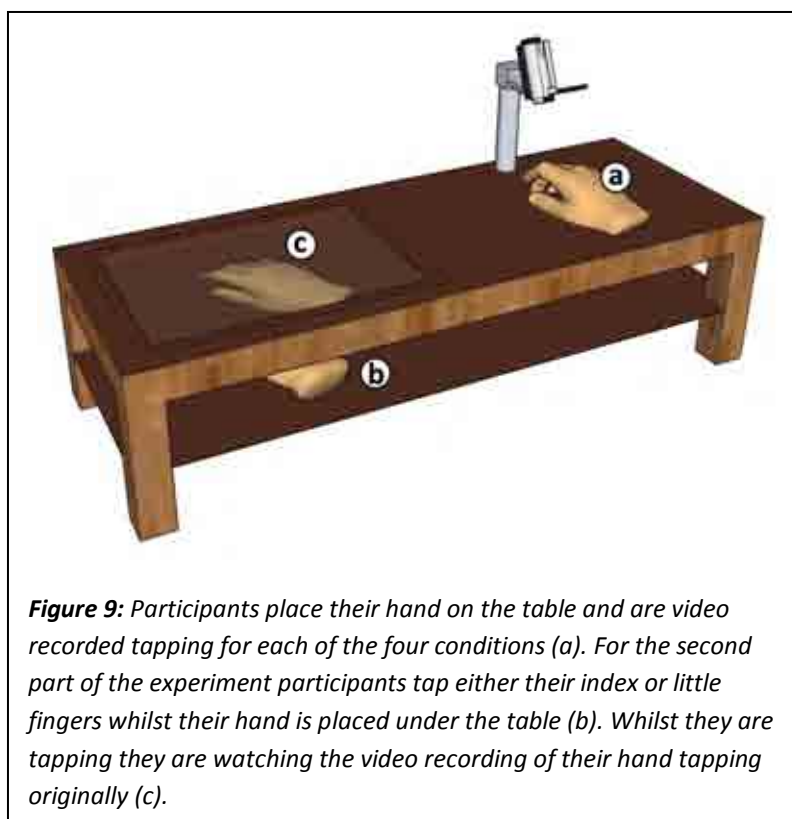
Participants

30 participants (27 female, 3 male; 3 left-handed; mean age = 19.03 yrs) were all fluent in English and were sampled through the University research participation scheme. The sample size is an appropriate size for a within subjects design compared with recent research in this field (Capelari et al., 2009). This participation scheme requires undergraduate psychology students to complete 30 hours of research participation in order to pass their academic year. All participants provided written informed consent and the study was approved by the University of Birmingham Ethics Committee.

Materials

Participants' tapping was recorded with a Sony Handycam Video Camera held at a fixed position overhead with a Manfrotto Tripod. Recordings were played back through a laptop computer

attached to a 19-inch LCD monitor. The monitor was held in place horizontally in a custom built polystyrene enclosure. This enclosure was surrounded in black cloth, matching the backdrop of the video recording to ensure an environment visually congruent to the video recording. Participants



tapped their fingers at 66 beats per minute, in time with a metronome. Participant's feelings of ownership and agency towards the 'video hand' were measured with Botvinick and Cohen's 7

item questionnaire (Botvinick & Cohen, 1998). A questionnaire devised from the qualitative findings of McCabe et al. (2005) was also completed to establish sensations participants felt whilst they were tapping. This questionnaire (Appendix C) consists of 9 items requesting participants to rate the degree of pain, discomfort, temperature, weight, and peculiarity of the sensation felt in their hand. This questionnaire also requires participants to rate whether they felt they had lost or gained a hand. All of these factors were identified by McCabe et al. as possible consequences of a sensory-motor conflict. Both of these questionnaires have been devised based upon the findings of Botvinick & Cohen (1998) and McCabe (2005). Neither of which have been tested for reliability or validity. Both of these questionnaires use a 7 point Likert Scale (-3 to 3) with ratings of 2 or 3 indicating strong or very strong agreement with a preceding statement (for example, "I felt pain").

Design

A two-way within-subjects ANOVA design was employed for each questionnaire. There were two independent variables: synchrony (consisting of two levels: synchronous and asynchronous) and question (consisting of 7 levels/statements for the Botvinick & Cohen questionnaire and 9 levels/statements for the McCabe questionnaire). The dependant variable was the extent participants agreed with each statement.

Procedure

Participants placed their dominant hand on a black cloth covering the table directly below the video camera. The video camera was positioned perpendicular to the participants hand and the table so that the whole hand and wrist could be captured. Participants were video recorded completing 4 tasks: tapping their index finger for 1 minute, tapping their little finger for 1 minute, tapping their index finger for 30 seconds followed by their little finger for 30 seconds and finally tapping their little finger for 30 seconds followed by their index finger for 30 seconds. Participants

tapped in rhythm to the metronome and for the latter two tasks were informed by the experimenter when to switch from tapping one finger to the other.

Once video recording was completed participants moved their dominant hand to a platform under the monitor. The four video recordings were then played back to the participant in a random order. The participant was asked to concentrate on the screen and tap the finger that is being tapped at the start of the video for the whole minute in synchrony with the rate it is being tapped. The metronome was not used in this part of the study as it would draw attention from the video. Instead participants had to concentrate on the tapping in the video to judge when they should tap themselves, therefore heightening attention to the video. For the two asynchronous trials the participant continues to tap the original finger throughout, whilst the video recording shows a switch between fingers after thirty seconds, showing the opposite finger tapping for the second half of the video. Therefore the participant for the second half of the video is performing an action incongruent to what they can see. After each recording has been played participants were presented with two questionnaires assessing the strength of the illusion (Botvinick & Cohen, 1998; McCabe et al., 2005) and were asked to complete them based upon the sensation they had felt during the final 30 seconds of the task. The whole session took 30 minutes for participants to complete.

Results

Descriptive Statistics

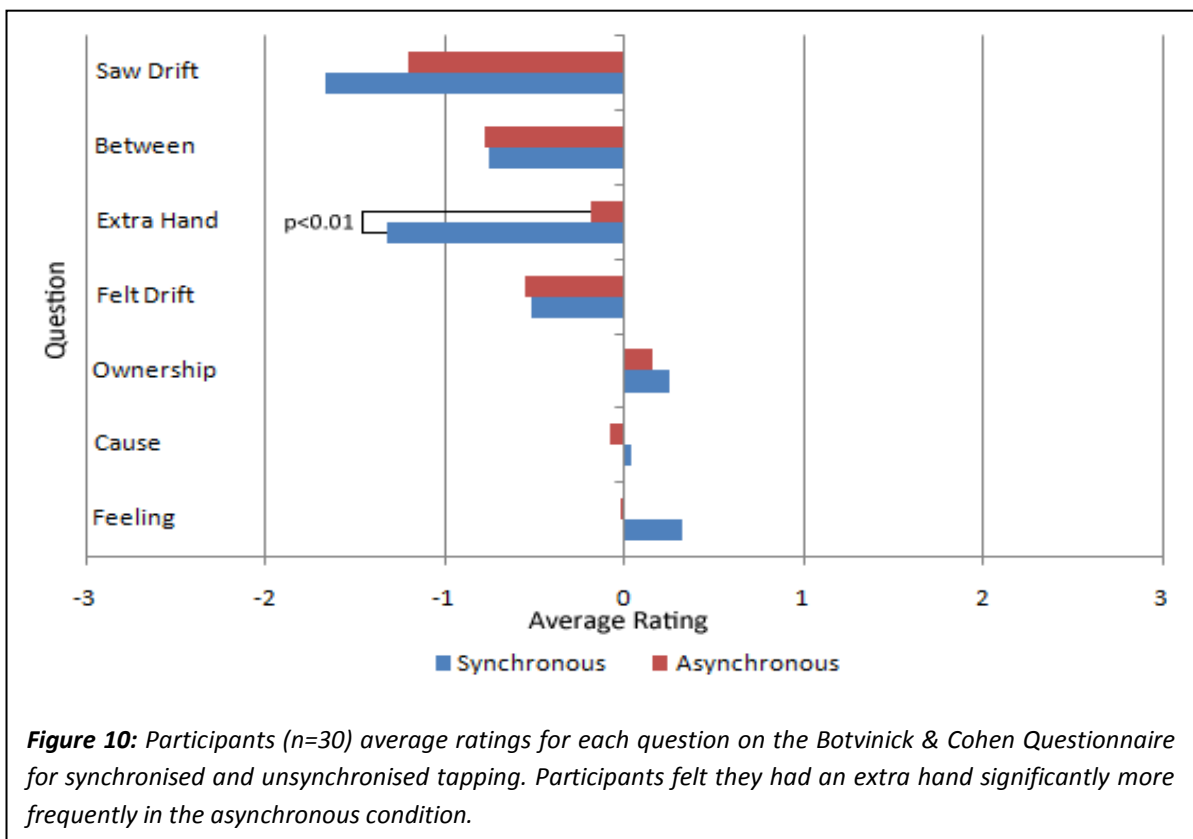
All participants completed both questionnaires; the percentage of participants who agreed with the statements on either questionnaire is shown below (Table 8).

Question		Significant Responses			
		Synchronous		Asynchronous	
		Index	Little	Index	Little
Botvinick & Cohen	It seemed as if I were feeling the tap of my finger in the location where I saw the recorded finger tapping	29%	24%	29%	23%
	It seemed as though my tapping was causing the recorded finger to tap	7%	21%	21%	17%
	I felt as if the recorded hand was my hand	36%	21%	33%	23%
	It felt as if my (real) hand was drifting upwards (towards the recorded hand)	29%	7%	18%	17%
	It seemed as if I might have more than one hand or arm	7%	7%	25%	30%
	It seemed as if the tapping was going on somewhere between my hand and the recorded hand	14%	10%	14%	10%
	It appeared (visually) as if the recorded hand was drifting towards my hand	7%	7%	7%	3%
McCabe	I felt pain	0%	0%	4%	3%
	I felt discomfort	0%	0%	25%	13%
	I felt as though I had lost my hand	0%	3%	4%	3%
	I felt my hand became hotter	14%	0%	11%	13%
	I felt my hand became colder	0%	0%	4%	0%
	I felt my hand became heavier	14%	10%	29%	23%
	I felt my hand became lighter	0%	0%	4%	0%
	I felt as though I had an extra hand	7%	3%	18%	10%
	I felt peculiar	29%	17%	54%	50%

Table 8: The percentage of participants ($n=30$) who agreed (responded +2 or +3) with the seven statements in Botvinick & Cohen's questionnaire (1998) and the nine statements in McCabe et al.'s Questionnaire (2005) is shown. These percentages are split between the four conditions: synchronous index finger, synchronous little finger, asynchronous index finger and asynchronous little finger.

Ownership and Agency: Botvinick & Cohen Questionnaire

The average ratings for each question and condition are shown in Figure 9. The effect of synchrony was insignificant as a main effect [$F(1,29)=0.59, p=0.45$] but it's interaction with questions was significant [$F(3.94,114.16)=3.68, p=0.008$]. Posthoc analysis revealed that in the asynchronous condition participants reported the feeling of an extra hand significantly more frequently than when in the synchronous condition [$t(29)=-3.823, p=0.001$].



Sensations: McCabe Questionnaire

The average ratings for each question and condition are shown in Figure 10. There was a significant main effect of synchrony [$F(1,29)=22.21, p<0.001$] and also questions [$F(4.47,129.61)=23.04, p<0.001$]. The interaction between synchrony and questions was significant [$F(4.85,140.54)=2.47, p=0.037$]. Posthoc analysis revealed significantly greater scores in

the asynchronous condition when asked about the peculiarity [$t(29)=-3.37, p=0.002$], discomfort [$t(29)=-3.47, p=0.002$], an extra hand [$t(29)=-3.49, p=0.002$], a lost hand [$t(29)=-2.66, p=0.013$] and pain [$t(29)=-1.43, p=0.044$].

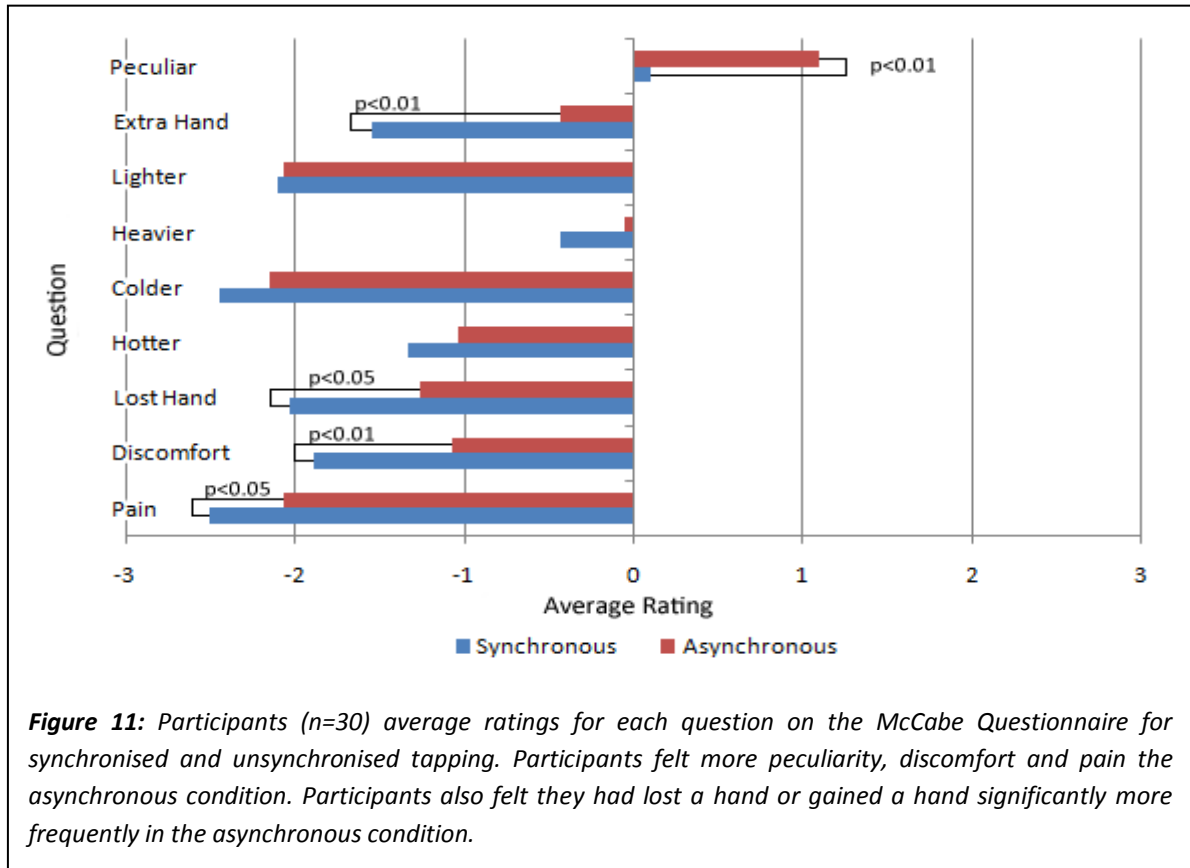


Figure 11: Participants ($n=30$) average ratings for each question on the McCabe Questionnaire for synchronised and unsynchronised tapping. Participants felt more peculiarity, discomfort and pain the asynchronous condition. Participants also felt they had lost a hand or gained a hand significantly more frequently in the asynchronous condition.

Discussion

Interpretation of the Results

The results of this investigation indicate that tapping incongruently to what you can see induces a heightened sensory experience (as determined by the McCabe questionnaire) than when tapping congruently. This heightened sensory experience can be defined as consisting of greater pain, discomfort and peculiarity. Intriguingly participants reported perceiving an extra hand or that they had lost a hand in the asynchronous condition, suggesting there is variance in how anomalies occur but can alter ownership and proprioception. This variance of ownership is also supported by a finding obtained with the Botvinick & Cohen questionnaire showing participants reporting ownership of an extra hand with significantly greater intensity in the asynchronous condition.

Critically, the questionnaires ask participants to report the intensity of the feelings by rating between -3 (completely disagree) and +3 (completely agree) with 0 defined as “neither agree nor disagree”. All significant findings other than peculiarity fell between -3 and 0, concluding that whilst there was a significantly greater experience in the asynchronous condition, this experience was simply less of a disagreement that it had occurred. The peculiarity statement, featured in the McCabe questionnaire was the only significant effect for which participants agreed that had occurred.

Limitations of the Results

In the case of occurrence of experience, experiences can *occur*, *occur to an extent* or *not occur*. In order to do this validly and clearly a scale between 0 and 10 (or any appropriate positive number) is required (0 = *no occurrence*, 5 = *occurring to an extent*, 10 = *occurred*). Both questionnaires used in this investigation have a negative component (-3 to -1) which can be misleadingly interpreted as *not occurring to an extent*, which is not possible. Participants

completing these questionnaires are forced to reinterpret the scales themselves as *no occurrence* (-3), *occurring to an extent* (0), and *occurred* (+3). If this is the case traditional interpretation of the questionnaire would mistakenly lead an investigator to believe the intensity of occurrence was milder than it actually was. This methodological limitation is likely to have hampered this investigations result, with many of the feelings of ownership or sensation occurring to an extent.

Suggestion of Further Research

This study needs to be replicated in order to ascertain whether the research measure has confounded the result. Incongruence between movement and sensation can clearly induce anomalous experiences including pain, but due to the confusing nature of the questionnaire the strength of these experiences remain unknown. The statements used in Botvinick & Cohen and McCabe's questionnaires revised to use a 10-point Likert Scale (between 0 and 10) will better test the extent to which participants experience altered sensation and ownership.

Through the use of a mirror or a projector this experiment can be replicated for use with fMRI. Comparison of activation in pain related regions in the brain such as the somatosensory cortex, thalamus, anterior cingulate cortex and parieto-insular cortex in participants who feel pain during incongruent movement will highlight the nature of this anomalous pain experience.

One purpose of this investigation is to produce a method that can reliably induce perceptual anomalies so their relationship with personality can be studied empirically. As this method can successfully induce externally generated perceptual anomalies in certain individuals further research is required to identify whether these individuals are prone to internally generated perceptual anomalies. If this is the case replication of this experiment with the incorporation of a personality inventory such as the MMPI or the NEO PI-R can push this area of interest further.

Conclusions

These findings support the work of McCabe et al. (2005) observing pain induced by an incongruent motor action in the general population. This investigation identifies this relationship from a quantitative standpoint (rather than the qualitative design used by McCabe et al.) and provides greater insight into the relationship between body ownership and anomalous sensations.

Currently this phenomenon has little neurophysiological explanation. Blakemore et al. (2003) when using hypnosis to induce motor incongruence found greater activation in the cerebellum and parietal cortex. Blakemore's model fails to incorporate the sensory component and specifically pain. Additionally studies of the rubber hand illusion have concentrated on perceived ownership of the fake hand (Botvinick & Cohen, 1998). This adaptation of the illusion has not induced false ownership, but anomalous sensations.

An inconsistency between sensory and motor information can lead individuals to feel a peculiar uncomfortable pain and can also induce the sensation of a lost hand or an extra hand. Evidence also supports that as well as the sensation of an extra hand, participants take ownership of this phantom hand. Because of the limitations of questionnaires assessing ownership and sensation it is hard to fully interpret the extent to which participants felt the anomalies. Only with refined methods and utilising neuroimaging techniques can these processes be understood.

Chapter Five

Conclusions

Summary of the Results

A battery of prior research has observed a relationship between pain sensitivity and four personality traits: hysteria, depression, hypochondriasis and schizophrenia. This investigation has identified hysteria and gender inversion as two personality traits that mediate the pain experience. It is surprising that only one of the four relationships observed in prior research is apparent in this investigation. It is also produced a surprising new relationship, that gender inversion and pain resilience are positively related.

Individuals who encounter varied, intrusive and frequent perceptual anomalies were observed to possess a pain sensitivity. The second experiment induced such a perceptual anomaly and found participants to experience greater pain than when the anomaly was absent. This relationship is intriguing and appears to be a result of anomalous experience inducing a heightened sensory state (Blakemore et al., 2003) that enhances pain sensitivity. It is plausible that individuals who encounter varied, intrusive and frequent perceptual anomalies encounter generalised heightened sensation which provokes their pain sensitivity.

Limitations and Further Research

The original aims of this investigation were to identify a collection of personality traits that are related to pain sensitivity in order to define a pain prone personality. The findings, contrary to certain literature identified only hysteria and gender inversion as the pain prone personality. The lack of observed relationships compared to the wealth of literature is possibly due to the age of the MMPI and the use of a sample heavily skewed towards a 20 year old female demographic. The original MMPI requires participants to respond to situations devised in the 1940's, many of which are irrelevant in 2010 and at best only provide a vague assessment of a participant's personality. The major limitation of the second investigation is the ambiguous questionnaires, using a Likert scale to assess a physical impossibility: whether an event *did not*

occur to an extent. The failings of these two self-report measures led to an inadequate assessment of participants, rendering the investigations results troublesome to validly interpret. With refinements of these two measures a valid pain prone personality can be established alongside a potentially stronger observed effect of anomalous perception on pain. Intriguingly two experimental measures testing for schizophrenia were completed by participants. The Cardiff Anomalous Perceptions Scale (CAPS) is a successful experimental measure for assessing anomalous experiences, but as these experiences are characteristic of schizophrenia, it can be presumed that participants with high CAPS scores possess heightened levels of schizophrenic tendencies (Bell et al., 2006). Due to the relationship between high CAPS scores and increased pain sensitivity it is clearly possible that there is a relationship between schizophrenia and pain sensitivity observed in this data. Only validation with a modern test for a schizophrenic personality such as the MMPI-2 can confirm this conclusion.

A further limitation of both investigations is poor control for gender with both investigations sampling fewer than 25% males. This shows little representation of the general population and consequently the result generalises better with females. This limitation has a large impact on the conclusions devised from the Gender Inversion Scale of the MMPI. As the majority of data is based upon female responses it is hard to determine whether the relationship between pain resilience and gender inversion is valid or whether pain resilience is simply related to masculine preferences. If the data represents masculine preferences this supports the popular conclusion that males possess a greater tolerance to pain (Riley, Robinson, Wise, Myers, & Fillingim, 1998). Whilst replicating this investigation specifically with the MMPI-2, consideration must be taken for representative gender sampling to avoid further ambiguous conclusions.

The Anomalously Perceptive Personality

The CAPS provides a breakdown of the variability, intrusiveness, frequency and distress that an individual encounters perceptually anomalous experiences. This measure is highly reliable

over a period of 6 months (Bell et al., 2006) indicating that these experiences are consistent events, with individuals regularly encountering the same levels of variability, intrusiveness, frequency and distress. As these consistent events are unique and exclusive to the individual they can be considered consistent behaviours, the underpinning of a personality. Cautious interpretation of these results is required when applied to episodic personality disorders, such as depression and bi-polar disorder. The CAPS assesses the frequency of our actions in specific situations in a similar format to a typical personality test. As these responses are consistent it is plausible that CAPS is assessing a trait or number of traits that comprise an anomalously perceptive personality. Whilst the introduction of such a personality is not groundbreaking this perspective broaches ground for further research. The CAPS provides scenarios that can be generalised to personality inventories. With detailed data of personality and anomalous perception, captured through one validated personality inventory, factor analysis can identify anomalous perception as a unique trait or a combination of various traits.

Relevance to Pain

The initial investigation highlights the flexibility of pain and how our personality traits and individual differences in part define our pain sensitivity. An unprecedented finding is that individuals who possess preferences of their opposing trait are more resilient to pain. This provides a new perspective in the study of gender and pain, sidestepping contemporary investigation of differences in biological sex. If sampling limitations have led to the identification of a masculinity based pain resilience this indicates that gender based pain differences have a psychological basis rather than biological. If conclusions based upon gender inversion are valid it also indicates a preference associated link with pain, introducing a new direction for pain research.

The finding that individuals who encounter greater perceptual anomalies experience greater pain sensitivity is curious, particularly as perceptual anomalies can illicit pain without

injury. This supports the notion that psychological factors are a key component in pain perception, but also indicates pain as a consequence to a heightened sensory experience.

Fibromyalgia is a condition frequently intertwined with reports of hysteria or emotional sensitivity (Villalpando, Sotres, Manning & Gonzalez, 2005). These personality traits may, to an extent be responsible for this condition. If this is not the case then these traits are likely to exacerbate fibromyalgia patients' pain (Gatchel, Polatin & Kinney, 1995). It is therefore important to identify patients possessing these traits and provide therapy to reduce them.

Personality based therapy can also be applied to chronic pain patients. Whilst there is no indication that personality may be responsible for patients pain it can certainly exacerbate it (Giescke et al., 2005; Wolfe et al., 2011). Cognitive Behavioural Therapy (CBT) is a highly effective therapeutic intervention for Fibromyalgia patients (Williams, 2003). CBT is frequently and successfully used to reduce anxiety and depression in Fibromyalgia patients (Williams, 2003). Incorporation of trait reduction of hysteria and gender inversion into these CBT programmes may enhance their success in alleviating Fibromyalgia symptoms. A wealth of evidence indicates a very strong relationship between chronic pain and depressive states, depressive personality or depressive disorders (Giescke et al., 2005; Schieir et al., 2009; Wolfe et al., 2011). A relationship between acute experimental pain and depression was not observed in this investigation. Further research is required to identify whether depression is only related to chronic pain and to understand why this mechanism fails to translate to acute pain.

As functional pain patients experience greater pain during perceptually anomalous experiences (McCabe, Cohen & Blake, 2007) it is important to identify whether this is due to an anomalously perceptive personality and if so how can medicine reduce these traits in an effort to relieve pain.

Relevance to Personality

These findings introduce the possibility of an anomalously perceptive personality. If this trait is independent of those defined by trait theorists it requires incorporation into their models. Incorporating these findings into existing popular models is important, as devising original, invalidated models is troublesome to apply to prior personality research. The introduction of this personality trait (or collection of traits) and the results of the initial investigation also highlight personality's interaction with physiological processes. Fundamentally personality defines our overt, observable behaviours, but in this case clearly alters pain sensitivity and potentially the frequency of anomalous experiences. Greater investigation is required to identify how personality affects physiological and perceptual activity.

Conclusion

The purpose of these investigations was to identify a pain prone personality in a controlled, objective experimental environment within the general population. This investigation establishes a pain prone personality comprising two traits, hysteria and gender inversion, and introduced a third trait or overall personality, an anomalously perceptive personality. Only further research can identify the composition and prevalence of this personality and the extent to which it alters the pain experience. With these questions answered investigation can centre on whether this trait is present in patient populations, particularly functional pain disorders such as fibromyalgia.

Glossary of Personality Traits

Agreeableness	Often compassionate, trusting, empathic and altruistic. Generally cooperative and pleasant in social situations.
Conscientiousness	Generally organised, persistent, controlling and motivated. Conscientious individuals are very self disciplined and strive for personal achievement.
Depression	Characterised by pessimism towards their lives and the future. Feelings of hopelessness and worthlessness are common, as is a preoccupation with thoughts of death and suicide.
Extraversion	[Opposite of Introversion] According to Myers involves focusing on the outer world. Displays frequent and intense energy in the social world. Extraverts are also gregarious, assertive and seek excitement. Eysenck also noted extraverts to be talkative and require large amounts of external stimulation.
Feeling	[Opposite of Thinking]. Bases their judgements on their feelings and emotions. This leads decision making to rely on more

meditative evaluations using better/worse or more/less methods of reasoning.

Gender Inversion

Individuals who present attitudes, interests and preferences of the opposite gender. Often individual's displaying high levels of this trait are homosexual. Levels of this trait are tested through the "Masculinity-Femininity Scale" of the MMPI.

Harm Avoidant

Characterised by anxiety, paranoia, shyness, tiredness and a pronounced fear of the unknown.

Hypochondriasis

An abnormal concern for their bodily functions and health. This anxiety damages the individual's quality of life, the range of activities they can perform and their interpersonal relationships.

Hypomania

It is characterised by a general over-activity, emotional excitement and racing thoughts. This over-activity can lead to great accomplishments but frequently induces inefficiency and unproductively.

Hysteria

The outward expression of physical symptoms as a mechanism for resolving emotional conflict or avoiding responsibility.

Recently patients presenting extreme levels of this trait would be diagnosed with Conversion Disorder.

Introversion	[Opposite of Extraversion]. Eysenck noted introverts to suffer from chronic over-arousal and consequently desire quiet solitary environments. Myer's model states Introverts also focus on ideas rather than the physical environment.
Intuition	[Opposite of Sensing]. Perceives the world through intuitive thought and acts on their own thoughts rather than the situation.
Judgement	[Opposite of Perception]. Characterised by relying on external rules to guide their lives in order for problems to be resolved quickly.
Neuroticism	[Opposite of Stable] According to Eysenck is a general negative affectivity manifested in depression and anxiety. Neurotic individuals are also highly self conscious and find it hard to control their emotions.
Novelty Seeking	Characterised by excitability, impulsiveness, extravagance and disorderliness.
Openness to Experience	Seeks hedonistic experiences and frequently engages in fantasy. These individuals are introspective and are open to their own feelings and ideas.

Paranoia	Commonly presents a persistent unrealistic and delusional suspiciousness. These delusions can also lead to feelings of grandeur or that they are being persecuted.
Perception	[Opposite of Judgement]. Handles the outside world by 'going with the flow' and acting on senses and intuition. This is a more relaxed outlook, with little anxiety for not reaching decisions or completing tasks immediately.
Psychasthenia	This trait is more commonly known as Obsessive-Compulsive Disorder (OCD). It is characterised by obsessive thoughts and compulsive rituals that hinder the patient's quality of life. This trait can also present with irrational fears, anxiety, a susceptibility to guilt and difficulty in concentrating.
Psychopathic Deviate	Typically amoral or asocial. Characterised by a frequent disregard for social custom and morals. Often these individuals fail to learn from their mistakes or negative experiences.
Psychoticism	Eysenck defines psychoticism as a collection of schizophrenic, psychopathic, obsessive, compulsive and paranoid sub-traits. Creativity is also a characteristic of a psychotic personality.
Reward Dependence	Characterised by a need for sympathy and approval. This trait also manifests in strong attachment and dependence bonds.

Schizophrenia	This trait is characterised by unusual and abstract thoughts or behaviour. It frequently presents with apathy, indifference and emotional isolation. Typically individuals presenting high levels of this trait suffer from hallucinations, delusions and disorientation
Sensing	[Opposite of Intuition]. Perceives the world through their senses, behaving as a response to the world around them rather than their unconscious thoughts.
Social Introversion	This is a more specific form of introversion where the individual can present with emotional introversion or extraversion but is consistently socially introverted. Generally social introverts are very conservative in social situations and deny many impulses and temptations.
Stable	[Opposite of Neuroticism]. Stable individuals can control and understand their emotions. They remain relaxed in stressful situations and overcome their problems logically and rationally.
Thinking	[Opposite of Feeling]. Bases their judgments on logic and thought. Individuals with this trait use true/false and if/then logical arguments to reach decisions.
Type A	Characterised by two components, the overt and the covert. The overt component elicits a general impatience and hostility in

trivial situations. The covert component is comprised of an innate insecurity and low self esteem.

Type B

A Type B individual displays the polar opposite traits to a Type A individual. It is characterised by emotional security, confidence and freedom.

Type D

Frequently known as the 'distressed personality'. Characterised by inhibition of emotion and anger alongside depression, social alienation and negative affectivity.

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Appendix A

**The Cardiff
Anomalous
Perceptions Scale**

Introduction

This questionnaire asks questions about sensations and perceptions you may have experienced. Some of the experiences are unusual, some of them are more everyday.

We realise circling answers may not always represent your experience as accurately as you might like. However, we would ask you to circle the answers that most closely match your experience and avoid missing any questions out.

We would appreciate it if you could be as honest as possible when giving your answers.

The only experiences we are not interested in are those that may have occurred whilst under the influence of drugs.

Instructions

Each item has a question on the left hand side. Please read the question and circle either YES or NO

- If you circle **NO** please move straight on to the next question.
- If you circle **YES** please rate the experience *in all of the three boxes* on the right hand side of the item by circling a number between 1 and 5.

These ask about how distressing you found the experience, how distracting you found it, and how often the experience occurs.

Example questions

You do not need to answer these questions, they are just examples to illustrate the instructions.

Do you ever notice that lights seem to flicker on and off for no reason ?

<input type="radio"/> NO <input checked="" type="radio"/> YES If YES please rate on right hand side.	Not at all distressing				Very distressing
	1	2	3	4	5
	Not at all distracting				Completely intrusive
	1	2	3	4	5
	Happens hardly at all				Happens all the time
	1	2	3	4	5

Do you ever feel that the sound on the TV or radio seems unusually quiet ?

<input type="radio"/> NO <input checked="" type="radio"/> YES If YES please rate on right hand side.	Not at all distressing				Very distressing
	1	<input checked="" type="radio"/> 2	3	4	5
	Not at all distracting				Completely intrusive
	1	2	<input checked="" type="radio"/> 3	4	5
	Happens hardly at all				Happens all the time
	1	<input checked="" type="radio"/> 2	3	4	5

1) Do you ever notice that sounds are much louder than they normally would be ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

2) Do you ever sense the presence of another being, despite being unable to see any evidence ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

3) Do you ever hear your own thoughts repeated or echoed ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

4) Do you ever see shapes, lights or colours even though there is nothing really there ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

5) Do you ever experience unusual burning sensations or other strange feelings in or on your body ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

6) Do you ever hear noises or sounds when there is nothing about to explain them ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

7) Do you ever hear your own thoughts spoken aloud in your head, so that someone near might be able to hear them ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

8) Do you ever detect smells which don't seem to come from your surroundings ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

9) Do you ever have the sensation that your body, or a part of it, is changing or has changed shape ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

10) Do you ever have the sensation that your limbs might not be your own or might not be properly connected to your body?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

11) Do you ever hear voices commenting on what you are thinking or doing ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

12) Do you ever feel that someone is touching you, but when you look nobody is there ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

13) Do you ever hear voices saying words or sentences when there is no-one around that might account for it ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

14) Do you ever experience unexplained tastes in your mouth ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

15) Do you ever find that sensations happen all at once and flood you with information ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

16) Do you ever find that sounds are distorted in strange or unusual ways ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

17) Do you ever have difficulty distinguishing one sensation from another ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

18) Do you ever smell everyday odours and think that they are unusually strong ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

19) Do you ever find the appearance of things or people seems to change in a puzzling way, e.g. distorted shapes or sizes or colour ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

20) Do you ever find that your skin is more sensitive to touch, heat or cold than usual ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

21) Do you ever think that food or drink tastes much stronger than it normally would ?

NO YES

If YES please rate on right hand side.

Not at all distressing					Very distressing
1	2	3	4	5	
Not at all distracting					Completely intrusive
1	2	3	4	5	
Happens hardly at all					Happens all the time
1	2	3	4	5	

22) Do you ever look in the mirror and think that your face seems different from usual ?

NO YES

If YES please rate on right hand side.

Not at all distressing					Very distressing
1	2	3	4	5	
Not at all distracting					Completely intrusive
1	2	3	4	5	
Happens hardly at all					Happens all the time
1	2	3	4	5	

23) Do you ever have days where lights or colours seem brighter or more intense than usual ?

NO YES

If YES please rate on right hand side.

Not at all distressing					Very distressing
1	2	3	4	5	
Not at all distracting					Completely intrusive
1	2	3	4	5	
Happens hardly at all					Happens all the time
1	2	3	4	5	

24) Do you ever have the feeling that of being uplifted, as if driving or rolling over a road while sitting quietly ?

NO YES

If YES please rate on right hand side.

Not at all distressing					Very distressing
1	2	3	4	5	
Not at all distracting					Completely intrusive
1	2	3	4	5	
Happens hardly at all					Happens all the time
1	2	3	4	5	

25) Do you ever find that common smells sometimes seem unusually different ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

26) Do you ever think that everyday things look abnormal to you ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

27) Do you ever find that your experience of time changes dramatically ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

28) Have you ever heard two or more unexplained voices talking with each other ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing
			1	2	3	4	5	
			Not at all distracting					Completely intrusive
			1	2	3	4	5	
			Happens hardly at all					Happens all the time
			1	2	3	4	5	

29) Do you ever notice smells or odours that people next to you seem unaware of ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

30) Do you ever notice that food or drink seems to have an unusual taste ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

31) Do you ever see things that other people cannot ?

NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

32) Do you ever hear sounds or music that people near you don't hear ?

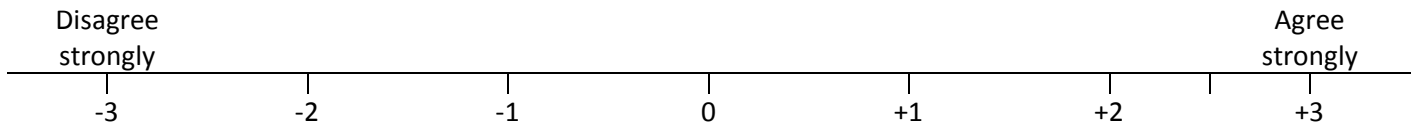
NO	YES	If YES please rate on right hand side.	Not at all distressing					Very distressing				
			1	2	3	4	5	1	2	3	4	5
			Not at all distracting					Completely intrusive				
			1	2	3	4	5	1	2	3	4	5
			Happens hardly at all					Happens all the time				
			1	2	3	4	5	1	2	3	4	5

Appendix B

**Botvinick & Cohen
Questionnaire
(Sensory)**

Modified Botvinick and Cohen questionnaire: Indicate your response to the following questions by circling the appropriate number ranging from “agree strongly” (+3) to “disagree strongly” (-3)

It seemed as if I were feeling the stroking of my hand in the location where I saw the stroking on the fake hand.



It seemed as though my stroking was causing the fake hand to be stroked at the same time.



I felt as if the fake hand was my hand.



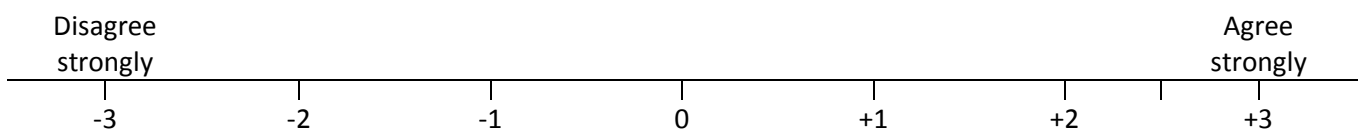
It felt as if my real hand was drifting towards the fake hand.



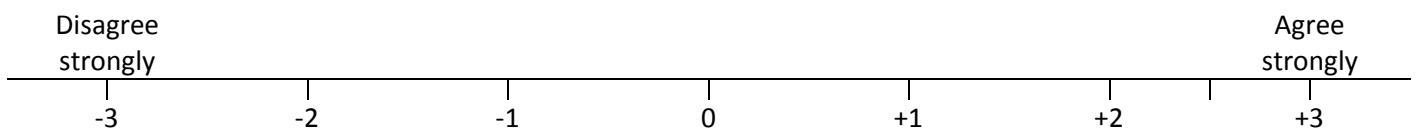
It seemed as if I might have more than one hand or arm.



It seemed as if the stroking was going on somewhere between my hand and the fake hand.



It appeared (visually) as if the fake hand was drifting towards my hand.



Appendix C

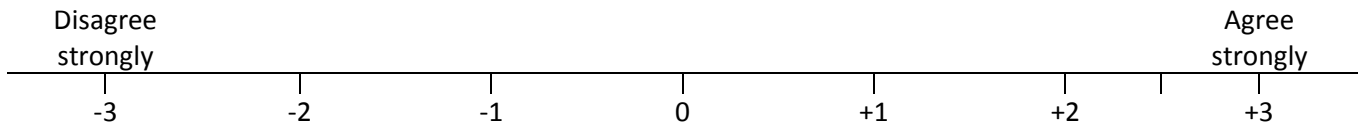
McCabe

Questionnaire

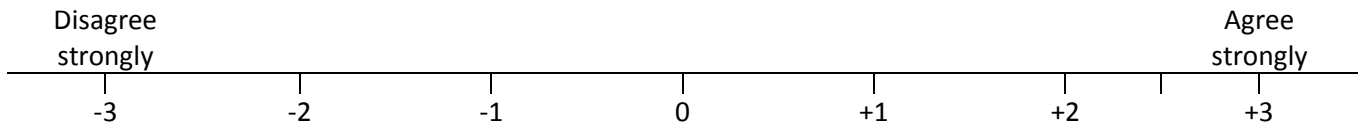
(Sensory)

McCabe questionnaire: Indicate your response to the following questions by circling the appropriate number ranging from “agree strongly” (+3) to “disagree strongly” (-3)

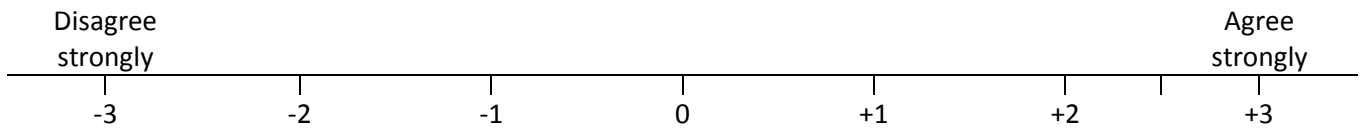
I felt pain



I felt discomfort



I felt as though I had lost my hand



I felt my hand became hotter



I felt my hand became colder



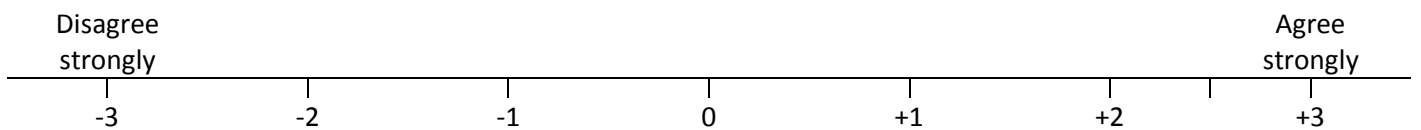
I felt my hand became heavier



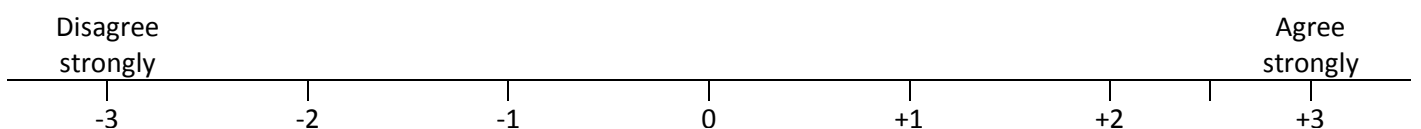
I felt my hand became lighter



I felt as though I had an extra hand



I felt peculiar

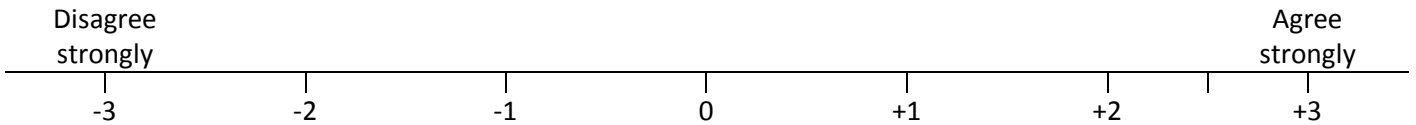


Appendix D

**Botvinick & Cohen
Questionnaire
(Motor)**

Modified Botvinick and Cohen questionnaire: Indicate your response to the following questions by circling the appropriate number ranging from “agree strongly” (+3) to “disagree strongly” (-3)

It seemed as if I were feeling the tap of my finger in the location where I saw the recorded finger tapping.



It seemed as though my tapping was causing the recorded finger to tap.



I felt as if the recorded hand was my hand.



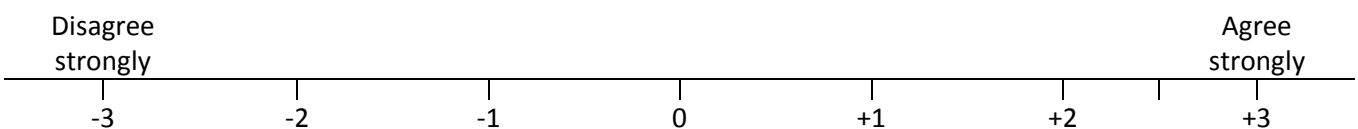
It felt as if my (real) hand was drifting upwards (towards the recorded hand).



It seemed as if I might have more than one hand or arm.



It seemed as if the tapping was going on somewhere between my hand and the recorded hand.



It appeared (visually) as if the recorded hand was drifting towards my hand.



Appendix E

McCabe

Questionnaire

(Motor)

McCabe questionnaire: Indicate your response to the following questions by circling the appropriate number ranging from “agree strongly” (+3) to “disagree strongly” (-3)

I felt pain



I felt discomfort



I felt as though I had lost my hand



I felt my hand became hotter



I felt my hand became colder



I felt my hand became heavier



I felt my hand became lighter



I felt as though I had an extra hand



I felt peculiar

