The effects of multiple forms of disgust exposure on the processing of emotional photographic images

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Declaration

I certify that the work presented in this thesis is my own original work and is for examination for the Doctor of Philosophy in Psychology degree.

Signature______________________________ Date_________________

This thesis is dedicated to Doreen Saddleton, who first inspired me to learn about psychology, and without whom (for reasons too numerous to mention or do justice to here) it would not exist. You are deeply missed.

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Abstract

Exposure to disgust has been found to influence both short term attentional processes and decision making. This thesis proposed to investigate the extent to which disgust exposure can also influence emotion processing and evaluation – specifically of real world photographic images. To this end, both behavioural and event related potential (ERP) paradigms were utilised. Disgust was induced in multiple ways – through videos, written scenarios and briefly presented prime images.

After exposure to disgusting prime images, participants high in disgust propensity were quicker to respond to disgust targets (a congruence effect that was not obtained for fear targets preceded by fear primes). After reading disgusting sentences, participants who were high in disgust propensity were more likely to judge pleasant food images (as well as disgusting images) as unpleasant (but not other pleasant images) thus reconfirming the relationship between disgust and digestion. ERP data revealed that individuals high in attentional shifting ability had a suppressed Late Positive Potential (LPP) to both disgusting and threatening images but that this effect was washed out through reading disgusting scenarios. After exposure to disgusting videos, attentional focus was associated with an increased LPP response to disgust (but not fear) images. There was a strong occipital LPP enhancement for disgust (over both fear and neutral) that was independent of disgust exposure and could represent an electrophysiological marker of disgust processing.

The results demonstrate that both the processing of disgusting images, as well as the processing of emotional images of a variety of content (both positive and negative), can be affected by disgust exposure. These effects can be seen early in processing and also influence later emotional assessments, and are strongly dependent on individual differences in disgust propensity and attentional control. The results highlight the extent to which disgust can influence multiple short-term emotion processing mechanisms.

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Chapter 1. Disgust: Forms and Function

1.1. Overview of the Chapter

This chapter introduces disgust as a subject in psychological research. The topics covered are the conceptualisation of physical disgust (i.e. the disgust experienced in response to objects or animals in the environment), the extension of disgust into the interpersonal sexual and moral domains, a discussion of the significance of the insula for disgust processing, and an overview of the state of research into disgust development in infants and children (and the implications for broader disgust theories). Before introducing disgust, however, it is necessary to first discuss the broader area of emotion, which has a rich history within psychology and a literature that continues to expand and grow at a staggering rate.

The first section of this chapter will outline the ways in which emotions have been conceived of within psychology and how theories of emotion have developed over time. The purpose of including this initial section is to give a brief overview of how emotions have traditionally been represented within the field and the broader context in which research on disgust takes place. This first section is intended to be relatively brief so that the remainder of the chapter can focus on disgust in more detail, and is intended simply to frame the discussion rather than being an in depth exploration of emotion within psychology. The second section will focus exclusively on disgust and introduce a broad discussion of the subject, leading into the more specific areas discussed in chapters two and three.

1.2. How Emotions Have Been Represented in Psychology

Emotional experience is readily referred to day-to-day and undoubtedly has a major impact on our psychological wellbeing; however, a common operational definition within the field of psychology (or indeed philosophy) has nevertheless been hard to come by. Kleinginna and Kleinginna (1981) identified 92 definitions of emotion in the psychology literature; these typically tend to be functional to the area under investigation (e.g. emotion is defined in terms of external triggers by studies examining the impact of emotional content in the environment, whereas cognitive or affective definitions – emphasising thought processes and verbally reportable feelings – are favoured when self-reported experience is the subject of research). Kleinginna and Kleinginna (1981) emphasised the likely multidimensionality of emotion and encouraged working towards a broad definition that was able to incorporate the various dimensions that had been identified.

While the psychological experience of emotion is clearly an essential aspect of the phenomenon (as it is the aspect we actually subjectively experience), many areas in the cognitive sciences tend to define emotions in terms of their proposed functions (i.e. the practical consequences of the associated physiology and the behaviours motivated by the experience). Darwin's 1872 book *The Expression of the Emotions in Man and Animals* (Darwin, 1872/1998) is frequently cited for its definitions of specific emotions (particularly disgust, as will be discussed in chapter 1.3), and the general approach of defining these experiences in terms of the associated physiology and expression and then the speculated adaptive advantages that are granted through these behaviours is a common one for operationalising emotions. With regard to behavioural responses (rather than physiology or expression), research of this nature often has the goal of associating specific emotions with particular action tendencies – for example, approaching a target as a result of feeling angry or retreating from it as a result of feeling fear (Frijda, Kuipers, & ter Schure, 1989).

The focus on the physiological state aroused by emotions was central to the classic James-Lange theory of emotion (James, 1884; Lange, 1885/1922) which emphasised the primacy of physiological responses to environmental triggers, and speculated that emotional experiences emerged from a subjective awareness of these changes compared to a baseline physiological state. The notion that the physiology associated with emotional experience precedes the experience itself was challenged in what is referred to as the Cannon-Bard theory (Bard, 1928; Cannon, 1927, 1931) which emphasised the importance of the activation of the thalamus in both generating an emotional experience and, in parallel, starting the cascade of neural changes necessary to produce the physiological responses associated with the emotional state.

Despite the differences in proposed mechanisms and direction of effect, the emphasis on physiological changes as a central component to emotion was consistent in both of these accounts. Theories of emotion have since been proposed that have a strong emphasis on conscious cognitive processes rather than automatic physiology. Schachter and Singer (1962) recognised the importance of physiological arousal for emotion but also argued that it was necessary for a particular cognitive interpretation of that experience to be made before an emotional response could be said to have arisen in the individual. This study demonstrated that differing emotions could be reported by individuals with the same induced physiological state as a result of the social and cognitive context in which the physiological arousal was experienced (though it is worth noting that Marshall & Zimbardo, 1979, failed to replicate these results). Likewise, the centrality of cognition for emotional experience has been argued by Lazarus (1982, 1991), who has highlighted the necessity for specific cognitive appraisals to be made of the situation before an emotion manifests psychologically. Research using paradigms that manipulate the context in which emotional experiences occur, so that alternative appraisals of the situation are made (e.g. Smith & Lazarus, 1993), are used to support this notion; however, it has also been suggested that, as a result of certain automatic sensory processes and associative learning mechanisms, particular affective responses to stimuli can be generated without such explicit cognitive appraisal (Zajonc, 1984; see chapter three for a more in depth discussion of emotional exposure effects).

Thus, emotion has been conceptualised in terms of its function, physiology, behaviour and cognition, and can be defined in all of these terms. Parkinson (1994) proposed a four factor model of emotional experience that incorporated appraisal (of some stimulus or situation), physiological arousal, facial expression and action tendencies and emphasised their interdependence. Though the extent to which these factors are determinants of, or contribute to, emotion is still debated, it is difficult to conceive of emotional experience without these elements to a greater or lesser extent being present (though it is worth noting that emotional expression can be masked – a concept referred to as *expressive suppression* by Gross, 1999, – even when an emotional experience is still present). Likewise, it is difficult to conceive of emotions without some form of pleasure or displeasure being part of the experience (as emphasised by the definition of emotion arrived at by Cabanac, 2002).

It is worth noting that emotions (in the psychological literature at least) tend to be represented as transient sensations that are provoked by an individual's interaction with their environment (as with the *appraisal* aspect of Parkinson's model); however, there exists a set of persistent psychological states, often described in emotional terms, that are not transient, nor necessarily coupled with some external stimulus or event. Researchers on *basic emotions* (a concept that will be discussed in chapter 1.2.1) such as Ekman (1992) do not consider what he refers to as *moods* (such as irritation), *emotional attitudes* (such as love), *emotional traits* (such as timorousness), *emotional disorders* (such as depression) or *emotional plots* (more complex pervasive interpersonal feelings such as jealousy) as emotions per se – largely due to their time course and the extent to which they are bound with more global trait characteristics in the individual. Discussions of whether this distinction is one that is theoretically justified are beyond the scope of this thesis; but as the research work presented here deals with an investigation of the brief affective response that arises in individuals as a result of processing emotionally provocative imagery in the environment (a response to specific images that tends to be referred to using a specific emotional term), the work in this thesis examines emotion only in terms of the intense transient psychological and physiological response that emerges after viewing emotionally delineated pleasant and unpleasant visual imagery.

1.2.1. Basic emotions and emotional expression.

The correspondence between an internal emotional experience and a specific facial expression has been long noted and the scientific investigation of this phenomenon has its roots in Darwin (1872/1998), who sought to examine the similarities in the facial (and non-facial) bodily responses that occurred when experiencing particular emotions across cultures. Darwin noted several commonalities in expressions across cultures and speculated that these physical behaviours may be, at least to some extent, evolutionarily rooted. Within psychology it was the research of Paul Ekman and colleagues – with their challenging of social anthropological theories of culturally transmitted emotional expressions – that appears to have led to the focus on the basic emotional categories still extremely prevalent in psychology. Ekman and Cordaro (2011) define *basic* emotions as emotions that are discrete (i.e. easily identifiable from each other) and that have evolved through adaptation to our surroundings, and list 13 criteria for determining whether a particular emotion is a basic one. The discreteness of these emotions was supported by research suggesting that experiencing particular emotions is associated with the manifestation of highly specific physiological markers (Ekman, Levenson, & Friesen, 1983). Central to this theory is the notion of universality in certain emotional expressions across cultures (see Ekman, 1973, for a summary of this research). Within psychology, this conception of universal emotions has been criticised on the grounds that outward emotional expressions do not always map the same internal emotional state, and on the grounds that it is possible to decompose basic emotions into component parts (such as valence, arousal and core affect; see Barrett, 2006, for a discussion of these topics and a broad discussion of potential flaws in Ekman's cross-cultural research).

While the universality of emotions, and the extent to which the evidence supports the notion that certain emotions can be considered *basic*, is a subject still debated, the basic emotions (and their corresponding expressions) outlined by Ekman have been the focus of a colossal amount of research in experimental psychology. A great deal of research frames emotion in terms of these particular labels and examines the corresponding behavioural, neural or cognitive profiles associated with them. Likely due to the ease with which they enable researchers to examine and target particular emotions visually, emotional facial expressions have been the stimuli most often used in emotion research in this field. The research presented here uses more complex visual imagery (real world photography) to evoke emotional responses in participants (see chapter four for more information on why these stimuli were selected) and the images selected for use were intended to target the specific discrete emotional categories represented typically in experimental psychology. Thus, this thesis will focus on emotions in terms of the English labels assigned to them and with reference to the emotional categories most commonly represented in the literature (i.e. the basic emotions defined by Ekman).

1.2.2. The influence of neuroanatomical theories of emotion.

The Cannon-Bard theory of emotion, with its focus on the thalamatic regions as emotion centres (centres that could be inhibited by neocortical regions under some circumstances), was an early neuroanatomical account of emotion. This focus on singular neural structures as emotion centres (or at least of highly specialised and contained neural circuits) shifted to accounts of large broader circuits and networks, and there have been numerous proposed circuits of emotion processing that followed the Cannon-Bard model.

The Papez circuit (Papez, 1937) was an influential early proposed emotion circuit that built on the Cannon-Bard theory. Like the Cannon-Bard model, this theory identified the thalamus as a key region for emotion and emphasised the parallel processing streams that emotion processing diverges into after the thalamus activates in response to an emotional stimulus in the environment. These parallel processing streams (one predominantly cortical and the other subcortical), connected neuroanatomically by major fibre tracts, instigate both emotional experience and prime appropriate bodily responses respectively. There is a feedback loop within the circuit which is defined by projections from the hypothalamus to the anterior thalamus, then to the cingulate cortex, then to the hippocampus, and finally a projection back into the hypothalamus (see Dalgleish, 2004, for an illustration of this circuit). Information from both streams is integrated at the cingulate cortex, and thus both streams have the capacity to influence emotional experience and prime bodily responses (though each stream is weighted towards influencing one of these processes). In contrast to the James-Lange account, neuroanatomical models of emotion such as the Papez circuit allow for a dissociation between the psychological experience of emotion and the bodily responses associated with it (such that an individual can experience a particular emotion under some circumstances even if the physiological response typically associated with that emotion is absent).

Many of these early anatomical accounts of emotion were developed following the discovery and conceptualisation of the *limbic lobe* (Broca, 1878), which can be defined as the subcortical ring of neural structures around the brain stem present in mammals. The function of this lobe and its influence on emotion processing and priming bodily responses to emotional stimuli in the environment was further elucidated in the *limbic system* theory articulated by MacLean (1952). Many of the structures identified in the limbic system (for example the amygdala, the hypothalamus and the cingulate gyrus) appear to be active during emotion processing (Murphy, Nimmo-Smith, & Lawrence, 2003; Phan, Wager, Taylor, & Liberzon, 2002) and their activation in fMRI data can (at least to some extent) distinguish basic emotions from each other (Vytal & Hamann, 2010). However, the historical conception of the limbic system as a highly specialised neural system for emotion processing has been undermined by more recent research showing that these limbic structures also have an important role to play in aspects of cognition such as memory (Calder, Lawrence, & Young, 2001). It is clear that although these structures play an important role in emotion processing, the neurons within these structures also contribute towards cognitive processes, and likewise, traditionally conceptualised regions associated with *higher* cognitive functions (particularly areas within the prefrontal cortex) have also been found to be prominent in emotion processing (see Pessoa, 2008, and Pessoa & Pereira, 2013, for an overview of this research). This focus on the interaction between cognitive and affective processing systems (systems that have been historically demarcated as separate areas of research) has resulted in theories that emphasise their interrelatedness such as the *somatic marker* hypothesis of Damasio et al. (Damasio, Tranel, & Damasio, 1991). Following this approach, psychological theories that emphasise the relationship between specific emotions and specific cognitive processes have also been developed (for example the moral foundations theory put forth by Haidt, 2007; see chapter 3.3 for a more in depth discussion of this theory).

The practice of averaging across participants in fMRI studies to pinpoint specific regions involved in the processing of specific emotions has also been questioned (Barrett, 2006) with the substantial individual variability indicating that key anatomical structures that have become almost synonymous with emotions (for example the amygdala with fear) often appear not to be activated in processing that particular emotion for some participants. It is possible that the tendency for these regions to activate in response to particular emotions is a consequence of their role in broader function; for example, in the case of the amygdala it has been speculated that activation may often represent the flagging of motivationally relevant stimuli (Sander, Grafman, & Zalla, 2003) of which fear stimuli is frequently an exemplar (rather than the amygdala being a specialised fear processing unit per se). However, despite the proposed broader function and the involvement with other cognitive processes, structures such as the amygdala do appear to be particularly sensitive to emotional information and while the amygdala may serve a broader function of salience signalling, salient events associated with emotional negativity or fear inducing threat do appear to increase its activation (Stillman, Van Bavel, & Cunningham, 2015; Vuilleumier, 2005). It is also worth noting that in spite of the level of variability between individuals in the functional activation associated with particular emotions, it does appear to be possible (to some extent) to identify when individuals are psychologically experiencing particular emotional states from neuroimaging data alone (Kassam, Markey, Cherkassky, Lowenstein, & Just, 2013).

The purpose of this section was not to provide an exhaustive account of the neuroscience of emotion (but see chapter 1.4 for a more in depth discussion of the neuroanatomy associated with disgust), but rather to give an overview of the ways in which emotion has been conceptualised with respect to neuroanatomy. The focus seems to have shifted over time from specific structures (or isolated networks) being associated with specific emotions to each basic emotion having a distinct neural profile (other cognitive neuroscience methods such as Magnetoencephalography (MEG) have shed further light on the extent to which these multiple functions emerging from the same brain regions emerge partially as a result of the time course of their activation; see chapter 1.4). The conceptualisation of emotion as both a conscious higher cognitive experience and as a more automatic physiological and behavioural response that serves a specific function (what Tomkins & McCarter, 1964, refer to as an *affect program*) are integrated in neuroanatomical accounts of emotion that emphasise the ways in which information from the environment is siphoned into multiple parallel neural networks that, while being somewhat specialised, are able to integrate and regulate one another. Recent *embodied emotion* theories (see Winkielman & Kavanagh, 2013, for an overview of this research area) also emphasise the extent to which cognition and emotion are entwined. Thus, neuroscientific research on emotion has underlined the interdependence between affective and cognitive functions and helped to frame this relationship with respect to specific emotional categories.

The aim of the chapter thus far was to give a description of how emotion has been represented within the area of psychology in which this thesis sits, and how emotion will be represented in the remainder of this thesis. The research reported in this thesis focuses on disgust, so the remainder of this chapter (and indeed the remainder of the thesis) will largely centre on this particular emotion.

1.3. Defining and Representing Disgust

As previously discussed, there has been some difficulty historically in defining emotion; this difficulty is actually magnified with disgust – as it has been found that people have particular difficulty articulating their reasons for finding physically disgusting stimuli unpleasant (Russell & Giner-Sorolla, 2011). *Disgust* is a label readily applied to a variety of unpleasant objects that may be encountered in the environment, though identifying the specific criteria that imbue a particular object with this characteristic is more difficult. A very common definition of disgust, which is frequently cited in introductions to research papers, is taken from Darwin (1872/1998) and represents disgust as “something revolting, primarily in relation to the sense of taste, as actually perceived or vividly imagined” (p. 250). Distaste has been identified as a central component of disgust by other prominent emotion researchers (Tomkins, 1963), though it has been speculated that the focus on taste is a consequence of the English word's etymology, and that disgust can be present without this oral element (see Miller, 1997, for a criticism of Darwin's conceptualisation and a very broad alternative phenomenological conceptualisation of disgust encompassing interpersonal and social aspects). It is worth noting that this often cited quote from Darwin linking disgust to distaste is followed up in the text by the clarification that disgust can also refer to a revolting sensation aroused "through the sense of smell, touch, and even eyesight" (Darwin, 1872/1998, p. 250) thus indicating that Darwin was aware that disgust could be induced through multiple sensory modalities. Darwin appears to use distaste as representative of the *internal sensation* experienced when confronted with a disgusting event or object, rather than suggesting that disgust is necessarily induced solely by food that offends the sense of taste. Darwin's formulation of disgust has also been criticised for being circular in its representation of disgust as both the reason for the response and the output of the response (Tybur, Lieberman, Kurzban, & DeScioli, 2013); this paper conceptualises disgust (at least for physical objects) in terms of the specific structure of the physiological systems that are activated in response to entities defined as disgusting. As with broad definitions of emotion, there are a number of levels on which disgust can be represented and (depending on the area of research) disgust can be defined broadly in terms of the internal functional architecture (as with Tybur et al., 2013), though it is more commonly represented quite narrowly in terms of the affective sensation provoked by certain stimuli or characteristics (for example, Zhong, Strejcek, & Sivanathan, 2010, define disgust more generally as “a common affective reaction to physical uncleanliness”, p. 859).

As many researchers are interested in disgust for the ways in which it influences aspects of behaviour and cognition (see chapter three for a discussion of this research), disgust is often provoked experimentally in participants through sensory exposure to external stimuli (such as images or smells). It may be partly because of this prevailing research focus that disgust tends to be defined as an affective response to (real or imagined) objects in the environment rather than in terms of the physiology that underpins the response or the functional mechanism that determines it. In this way, disgust is similar to fear in that it is closely defined as a response to specific environmental cues (for example, Ekman & Cordaro, 2011, represent fear as a response to "threat of harm, physical or psychological", p. 365). The fact that emotions such as happiness and anger are more difficult to explicitly tie to specific environmental triggers (and when they are tied to the environment, tend to rely on an explicit appraisal of a complex situation) may partly explain why individuals are more able to articulate the motivation behind these appraisals but find difficulty in articulating their reasons for feeling disgusted.

Despite the frequent description of disgust as simply a sensation experienced in response to an environmental cue, many researchers define disgust as an avoidance mechanism that is provoked by proximity to such an environmental trigger – Rozin (1999) represents disgust as a food rejection response that can be directed at non-food objects. This is a fairly typical view of the mechanism of disgust and conceptualisations of this particular emotion (that have a focus on function) typically define disgust as a mechanism for avoiding spoiled food (or contaminants more generally). Although disgust is certainly the label used to describe the unpleasantness associated with spoiled food (amongst other things), it is more difficult to represent disgust in terms of a functional avoidance mechanism (rather than simply as an affective response to particular objects in the environment) as this requires additional supporting evidence. Defining disgust in terms of an *evolved* functional mechanism seems to be even more difficult to substantiate as this makes further assumptions about the nature of emotions – with theories representing emotions as biologically transmitted programs being behoved to explain why precluding (or at least marginalising) developmental or cultural accounts of emotion is justified. However, there is clear evidence that the facial expression made in response to feeling disgusted does indeed appear to reduce the likelihood of ingesting (orally or otherwise) contaminants through a combination of reducing eye exposure to the environment, restricting nasal inspiratory capacity, and preventing contaminants entering the mouth (Fessler & Haley, 2006; Rozin, Nemeroff, Horowitz, Gordon, & Voet, 1995; Susskind et al., 2008). This focus on disgust as a disease avoidance mechanism was investigated by Oaten, Stevenson, and Case (2009), who examined several hypotheses that were consistent with a disease avoidance account of disgust and found broad support across the literature for the notion that disgust was evoked primarily in response to objects (or people) that contain features that were suggestive of disease. This disease avoidance function has also been speculated to be a major part of the reason why disgust appears to be strongly associated with a range of psychopathologies (see Davey, 2011, for a discussion). Alternative explanations as to the function of disgust (at least as far as it applies to objects in the environment as opposed to the more complex interpersonal disgust) appear to be lacking. At this point the evidence does seem to broadly support the notion that, in terms of function, disgust is best conceived of as a contaminant avoidance mechanism.

Ekman included disgust in his list of basic emotions and also focussed on the ingestion aspect – defining disgust as an aversive reaction provoked by the "sight, smell, or taste of something" (Ekman & Cordaro, 2011); Ekman extended his definition of disgust by asserting that it can also be provoked by offensive people or ideas. The fact that the language of disgust is often utilised to describe events or objects that are far away from the domain of environmental contaminants has been a subject of a great amount of research in recent years and is the focus of the next section of this thesis (chapter 1.3.1). While the extent to which disgust can be extended to other domains, and the extent to which physical disgust is decomposable into specific subcomponents, remain subjects of increasing debate in the literature, there does appear to be a broad consensus within experimental psychology that the most basic form of disgust can be conceptualised as an unpleasant aversive reaction to a specific set of environmental stimuli that are judged (whether consciously or through a more implicit pattern detection system) to contain contaminants of some type (whether in the form of rotten food, faeces or disease carrying animals and people). This aversive reaction provokes the typical physiological and behavioural characteristics associated with disgust, some of which have been identified as far back as Darwin (1872/1998), and include the typical disgusted facial expression of a wrinkled nose, narrowed eyebrows and a curled lip (in some cases with a protruding tongue; Ekman & Friesen, 1978; Rozin, Lowery, & Ebert, 1994), but also including an increased activation of the parasympathetic nervous system (de Jong, van Overveld, & Peters, 2011) and the typical avoidance behaviour associated with evading further contact with the offending object out of fear of contamination (Deacon & Olatunji, 2007; Woody & Tolin, 2002).

1.3.1. Physical disgust beyond simple distaste.

The contaminant avoiding disgust that is evoked by physical objects in the environment is often distinguished from other forms of disgust and this basic physical disgust (often termed *core disgust* when in response to the threat of oral incorporation – Rozin, Haidt, & McCauley, 2000, and distinguished from interpersonal or moral disgust) is the form of the emotion that appears to be broadly agreed upon among emotion researchers (at least within psychology). However, there are other affective terms that are also used to describe oral rejection of spoiled foods such as *distaste*. Whether terms such as this are simply synonymous with disgust or whether they represent a different psychological state is difficult to determine. Rozin et al. (2000) does distinguish between distaste (as a rejection based on sensory properties) and disgust (as the rejection based on specific knowledge surrounding the elicitor). It is speculated that distaste is an evolutionary precursor to disgust that also exists in animals (Rozin & Fallon, 1987; Rozin et al., 2000). Beyond distaste and disgust, Rozin et al. (2000) also highlighted a distinctly human category of physical disgust that was speculated to evoke the emotion in response to elicitors that reminded the individual of their animal nature; these elicitors included sexual acts, hygiene, dead animals or people, and body envelope violations (such as mutilation).

This work on classifying the domains of physical disgust has been expounded on and it has been speculated that disgust is partly composed of *core*, *animal reminder* and *contamination* subcategories (Olatunji, Haidt, McKay, & David, 2008). In this conceptualisation of disgust, core disgust refers to specifically oral elicitors, whereas animal reminder disgust refers to elicitors that provoke thoughts about our animal nature (including our death); contamination disgust is broadly the disgust associated with proximity to an entity that has previously had contact with a disgusting person or object and is primarily motivated by contaminant avoidance. The concept of animal reminder disgust is in line with earlier disgust theory (Haidt, McCauley, & Rozin, 1994; Rozin, Lowery, Imada, & Haidt, 1999) that speculated that there was a category of human disgust evoked by reminders of the animal nature of man that served the sociomoral function of protecting individuals from violations of *divinity* or *purity* (violations identified by research into morality – Shweder, Much, Mahapatra, & Park, 1997).

This concept of animal reminder disgust (particularly as it is conceived of as a form of disgust that protects against impurity) has been criticised for being inconsistent with the evidence. Tybur et al. (2013) pointed to a similar aversive response to corpses among animals (Wagner, Stroud, & Meckley, 2011) and the lack of disgust response to many other behaviours that should be animal reminders (such as sleeping or breathing). Across a series of six studies, Kollareth and Russell (2016) examined this concept experimentally and found that there was no relationship between being reminded of being an animal and feeling disgusted, and even found that animal reminder sentences that were pleasant (such as a baby responding happily to being tickled in the same way a pet dog would) served as more of a reminder of participants' animal nature than did unpleasant animal reminders (despite not being disgusting). It has thus been argued that the conception of animal reminder disgust is ill conceived, particularly given the possibility that humans may not avoid animal reminders at all (Royzman & Sabini, 2001). The relationship between disgust and purity violations has also been questioned, with an alternative account suggesting that the disgust provoked by supposed divinity violations can in fact simply be represented as core disgust (Royzman, Atanasov, Landy, Parks, & Gepty, 2014). The criticism by Royzman et al. (2014) highlights the extended use of pathogen related disgust elicitors to evoke disgust in the scenarios intended to represent violations of purity in this line of research. Royzman et al. (2014) also provided evidence that once elicitors related to core disgust were removed (but violations of divinity remained), participants were more likely to report anger, rather than disgust, as the emotion they experienced for such transgressions. Thus, although disgust is evoked by these transgressions, it seems plausible that it is the physical environmental elicitors (such as bodily fluids and human remains that were present the divinity scenarios utilised by Rozin et al., 1999) that evoke the aversive response in participants. The disgust evoked by moral transgressions will be discussed in more detail in chapter 1.3.3; however, given that conceptions of animal reminder disgust and the disgust evoked by divinity violations appear to be (at least partially) rooted in the more general physical disgust for pathogens, they do appear to be extensions of physical disgust to other objects in the environment rather than a more social form of disgust. The types of disgust described in the upcoming sections (chapters 1.3.3 and 1.3.4) are necessarily related to interpersonal interactions and thus constitute types of disgust evoked by more complex social judgements and assessments (particularly in the case of moral disgust).

1.3.2. Sexual disgust.

Given the previously described function of disgust as a pathogen avoidance mechanism, it is not surprising that this particular emotion has also been implicated in avoiding unwanted sexual contact (including sexual transmissions) that could have the potential to risk contamination in the individual. In the formulation of disgust put forward by Rozin et al. (1999) sexual disgust is subsumed under the (previously described) animal reminder disgust category. This categorisation of disgust at sexual practices being one related to reminders of our animal nature was also asserted by Olatunji, Haidt, McKay, and David. (2008). Although sexual disgust is often represented as a mechanism for avoiding unwanted sexual contact (for a variety of potential reasons) or as an aversion to particular sexual practices (such as incest), this account of sexual disgust as a reminder of the animal nature of human beings should bring with it the prediction that disgust will be evoked in response to these sexual scenarios independently of interpersonal factors (given that reminders of our animal nature should be evoked regardless of the sexual practice or the individuals involved). It may be the case that sexual disgust is evoked specifically for the purposes of avoiding infectious sexually transmitted diseases in the organism (as described by Oaten et al., 2009), or it could simply be a by-product of aspects of sexual practice containing disgust elicitors and activating the disgust system as an incidental consequence (Miller, 1997; Royzman et al., 2014; Royzman & Sabini, 2001). Indeed, there is considerable overlap in functional activation between the regions that process pornographic images, and the ones that process disgust (Borg, de Jong, & Georgiadis, 2014). Regardless, it does seem clearly to be the case that some aspects of sexual practice (or sexual practices between certain individuals) are able to evoke the same sort of disgust response in individuals that is also evoked by exposure to more inanimate environmental stimuli.

Tybur et al. (2013) constructed an evolutionary psychological model that attempted to account for sexual disgust. Under this account, a pathogen related disgust response (defined as the propensity to avoid disease carrying organisms, and similar to the *core* disgust previously described) emerges first phylogenetically (a view also espoused by Schaller & Duncan, 2007, who conceptualised disgust as an evolved *behavioural immune system*). Sexual disgust is an expanded form of this pathogen related disgust and co-opts the architecture of this more ancient disgust for the purpose of avoiding sexual partners that have the potential to jeopardize the organism's fitness. The sexual disgust response manifests as an output following additive unfavourable internal assessments of *genetic compatibility* and *mate quality* (as described by Jennions & Petrie, 2000, Neff & Pitcher, 2005 and Zeh & Zeh, 1996). Tybur et al. (2013) argue that disgust is a more appropriate and efficient emotional response to the assessment that a potential partner is of low sexual value than other emotions associated with avoidance (such as fear). The *fight or flight* response associated with fear either does not avoid contact with the potential sexual partner, or (in the case of the flight response) is metabolically costly and inefficient. Similarly, anger is rejected as an appropriate response as its behavioural outcomes (e.g. aggression) tend to put the organism at unnecessary risk. By adopting the physiological and behavioural responses typical of pathogen related disgust, and many of the elements associated with its internal architecture, and applying them to the sexual domain, it is speculated that an efficient system for avoiding sexual partners that jeopardise reproductive success and that do not put the organism at undue risk evolved over time.

This model does appear superficially difficult to falsify, but it provides an alternative to the animal reminder account of sexual disgust that appears more consistent with the circumstances in which sexual disgust actually manifests. Sexual disgust does appear to motivate avoidance of sexual partners who are biologically suboptimal (such as animals or relatives in the more extreme cases) and levels of sexual disgust appear to be correlated with conception risk across the menstrual cycle in women (Fessler & Navarrete, 2003). It is difficult to speculate as to the precise timeline of disgust and its related subdomains evolutionarily, but it does appear to be the case that sexual disgust functions to protect the organism from increased risk of sexual transmission and to avoid adverse genetic consequences for future generations.

1.3.3. Moral disgust.

Similar to core disgust, sexual disgust does appear to be shackled to specific environmental triggers that are consistent with the conceptualisation of disgust as an evolved pathogen avoidance mechanism; however, the disgust experienced in response to particular sociopolitical evaluations is more difficult to describe in these terms. The language of disgust is certainly utilised by people (in English speaking countries) when describing moral decisions that they disapprove of, but the extent to which this is merely a facet of the English language has proved difficult to determine. Nevertheless there has been a considerable amount of research into moral disgust over recent years and many theories of moral disgust have been posited.

Ekman and Cordaro (2011) define *contempt* as "feeling morally superior to another person" (p. 365) and classify it as a discrete basic emotion entirely separate from disgust;

however, this definition does not seem to capture the strong unpleasant offence that is typically associated with the term (for example the Oxford English Dictionary defines contempt as "the holding or treating as of little account, or as vile and worthless"). Darwin (1872/1998) also distinguished between disgust and the collection of interpersonal emotions represented by the terms *contempt*, *scorn* and *disdain*; however, Darwin did note that extreme contempt (or *loathing contempt* as he termed it) "hardly differs from disgust" (p. 250) and thus did appear to recognise that physical disgust and interpersonal contempt (at least in the extreme form) were very similar. The overlap between these systems has been recognised in research highlighting the oral nature of moral disgust and demonstrating that, like physical disgust, it is associated with the activation of the levator labii muscle associated with the curling of the lip and the wrinkling of the nose to produce the classic disgusted expression (Chapman, Kim, Susskind, & Anderson, 2009).

Moral disgust has been incorporated into broader disgust models for decades and has become central to some conceptions of moral psychology. The classic contempt, anger, disgust theory (CAD; Rozin et al., 1999) distinguishes between these three emotions and proposes that contempt is the emotion associated with moral violations of the community code, whereas anger underpins moral violations of autonomy, and disgust is experienced in response to violations of purity (as previously discussed). Within this formulation, contempt is distinguished from anger and disgust as an emotion without an animal origin and that signifies negative social evaluation. This account is based on prior work identifying the three emotions as part of the *hostility triad* (Izard, 1971, 1977) that are speculated to underpin everyday social disapproval.

There have been many other prominent proposed models of moral disgust. Tybur et al. (2013) proposed that, similar to sexual disgust, moral disgust co-opted the internal architecture of the pathogen related disgust system in order to protect against individuals within a social group that threatened the fitness of the group members. In this account of moral disgust, the disgust sensation is evoked as a result of judging an action (consciously or otherwise) as being of poor fitness value; subsequent disgust related behaviours (such as producing the disgusted facial expression) serve as communication tools to inform other members of the group of this disapproval and to signal for group action to be taken. As with the sexual domain, disgust is speculated to be the co-opted emotion as a result of being the emotion that most effectively strikes the balance between communicating disapproval and producing behaviours that do not put the individual at undue risk (e.g. through excessive aggression). Thus, a disgusted expression, in the context of a moral situation, is a signifier to other members of the group that the individual opposes the moral act in question and wishes to recruit others in punishing and condemning the transgressor. An alternative social functionalist account of moral disgust holds that rather than signalling for *condemnation*, disgust signals to the group that a particular individual is to be *avoided* as they represent a source of potential harm (Hutcherson & Gross, 2011). Other researchers have also come to the conclusion from a review of the literature that disgust is an emotion that has been adapted from its primary role of directing the avoidance of physical contaminants to also being the sensation experienced in response to moral disapproval (Olivera La Rosa & Roselló Mir, 2013; Pole, 2013).

The notion that disgust underlies moral condemnation is one that has met with substantial criticism however. As previously discussed, Royzman et al. (2014) found in a series of studies that anger attributions were far more common for moral violations of divinity once physical disgust elicitors were removed from the moral scenarios being used to represent divinity violations. Study two in this series also suggested that anger, not disgust, was the primary emotional label chosen in response to community violations (not contempt or disgust). Kayyal, Pochedly, McCarthy, and Russell (2015) also found from correlational studies that anger, not disgust, was the emotion that most strongly underpinned assessments of immorality; this study also supported Royzman et al. (2014) in suggesting that the disgust label tended to be assigned predominantly to moral scenarios that implicated potential pathogen transmissions. Some methodological issues have also been highlighted in the paradigm used in the original Rozin et al. (1999) paper; by prefixing the term *moral* to the emotion *disgust* as a response option, but not using this prefix for anger or other emotions, it could be that *moral disgust* responses were artificially inflated among participants who were deciding upon appropriate responses to *moral* violations (Russell, Piazza, & Giner-Sorolla, 2013). Russell et al. (2013) demonstrated that affixing the *moral* adjective to the other emotions as response options resulted in an increased level of their selection as appropriate responses to moral violations (this even applied to emotional labels not typically associated with moral violations such as fear and anxiety). Thus, there is reason to believe that anger is the primary emotion evoked by moral transgressions and that disgust attributions are more commonly given for moral scenarios as a result of them containing physical disgust elicitors or as a result of the research paradigms biasing responses towards moral disgust.

It is clear that, regardless of whether or not these emotions underpin morality, anger and disgust are often attributed to assessments of immorality under differing circumstances. Russell and Giner-Sorolla (2013) examined how these emotions contribute to moral evaluation and concluded that disgust for bodily transgressions was an unreasoned emotion (an emotion that is not underpinned by an elaborate reasoned assessment of the transgression). The central argument posited in this paper is that core and sociomoral elicitors of disgust do not provoke exactly the same emotion, and that sociomoral assessments share a considerable amount of variance with anger – as evidenced by Simpson, Carter, Anthony, and Overton (2006) who found comparably elevated anger and disgust ratings in response to presentations of sociomoral disgust elicitors. Simpson et al. (2006) also found that disgust for core elicitors weakened over time, in contrast to sociomoral elicitors which intensified. Russell and Giner-Sorolla (2013) propose that disgust is a separate moral emotion from anger only when it is experienced in response to bodily moral violations. Bodily violations are represented as situations where "moral codes related to the body are violated" (p. 328) and examples of bodily disgust elicitors include bodily waste products, eating violations (such as cannibalism) and sexual taboos (such as incest or paedophilia). In this formulation, bodily disgust would appear to subsume the sexual disgust category posited elsewhere (Tybur & Lieberman, 2016; Tybur et al., 2013), though it is also important to note that the bodily violation disgust described by Russell and Giner-Sorolla (2013) is directed towards the behaviours of third party actors, whereas the sexual disgust described by Tybur and Lieberman (2016) represents a disgust towards the thought of one's own first person potential acts. The disgust (rather than anger) sometimes attributed to non-bodily violations by individuals is hypothesised by Russell and Giner-Sorolla (2013) to be either a function of problems with forced choice research designs in the area (including research utilising disgust, but not anger, as a response option such as with Danovitch & Bloom, 2009), or a result of the considerable overlap that exists in the disgust and anger lexicon (with cluster analysis research such as Shaver, Schwartz, Kirson, & O'Connor, 1987, suggesting a good fit for modelling disgust as a subcategory of anger). The notion of bodily disgust as *unreasoned* is consistent with earlier work showing how disgust is less likely than anger to be justified with reference to external reasons or context (Russell & Giner-Sorolla, 2011). Thus, in this formulation of moral disgust, disgust is only evoked when it is experienced associatively in response to physical or bodily elicitors; the elaborate sociomoral condemnation beyond bodily norm violations is judged to be more parsimoniously represented as the emotion of anger.

Chapman & Anderson (2013) outlined three potential models based on appraisal theory (Arnold, 1960; Lazarus, 1966) that accounted for the relationship between distaste, disgust and morality, and concluded that the model favouring a single processing system for all three appraisal types was untenable. The models representing *intersecting* or *distinct* appraisal systems linked to a common output were favoured as they were consistent with studies on the overlapping neural systems active when processing both disgust and morality (see chapter 1.4 for a discussion of the neuroanatomy associated with disgust), and with studies suggesting that disgust is evoked even for *pure* moral transgressions where no disgust elicitor is present (e.g. Jones & Fitness, 2008; Olatunji, Tolin, Huppert, & Lohr, 2005). All of these three evaluated models also included a contribution to moral judgement outputs from a separate moral evaluation system that was not related to disgust (a system appraising morality less affectively), thus indicating that there are other active psychological systems (beyond disgust) that contribute to morality assessments. The proposed *intersecting* and *distinct* appraisal system models may offer a partial resolution to the question of the extent to which disgust and morality are intertwined as they are consistent with the available data and are capable of generating very specific scientific predictions for future research (a number are posited by Chapman & Anderson, 2013).

The extent to which the disgust and moral evaluation systems overlap (or do not) remains an open question, as does the question of the extent to which differing domains or morality evoke either disgust or anger. There is certainly a considerable body of evidence suggesting that exposure to disgusting stimuli is associated with short-term changes to moral judgement (a subject discussed at length in chapter three), but the available evidence does seem to suggest that there is some difference in the disgust experienced (either discreetly or in terms of intensity) when moral judgements involve appraisals of events containing physical or sexual disgust elicitors and the emotion experienced in situations where no such elicitors are present and a more externally elaborated moral judgement is provoked. Nevertheless, it does appear to be the case that arriving at moral judgements can, in some circumstances, be reliant on the activation of some of the internal architecture associated with disgust (some of this overlap in neuroanatomy is described in the upcoming section).

1.4. Disgust and the Insula

Given the relationship to distaste, it is not surprising that meta-analyses on the neural correlates of basic emotions (Murphy et al., 2003; Vytal & Hamann, 2010) tend to find the most consistent clusters of activation for disgust are in the bilateral insula (a structure known to be strongly implicated in distaste – Pritchard, Macaluso, & Eslinger, 1999). The insula is also associated with other functions and is implicated in various aspects of interoception (the ability to accurately sense the physiological state of the body; Critchley, Wiens, Rothstein, Öhman, & Dolan, 2004; Farb, Segal, & Anderson, 2012) and pain detection (Baliki, Geha, & Apkarian, 2009), and it is also linked to the activation of the sympathetic and parasympathetic nervous systems (Oppenheimer, Gelb, Girvin, & Hachinski, 1992; Critchley, 2005). Given that aspects of interoceptive awareness, parasympathetic activation and strong visceral aversive response form part of the physiological and phenomenological aspects of disgust, it is not surprising that there is some overlap in the neural activation that underpins disgust and the activation that underpins these broader related functions. Although the insula is often associated with disgust, a meta-analysis by Phan et al. (2002) found that insula activation was representative of processing of negative emotions more generally and instead found that disgust was specifically associated with activation in the basal ganglia. As previously discussed, neuroimaging studies of basic emotions reveal a considerable degree of individual variability; these studies on emotion also have the problem of using discrepant task paradigms and stimuli sets making comparisons between studies difficult. Regarding the insula activation, time sensitive magnetic field tomography methods may elucidate these neuroanatomical findings, and there has been some suggestion that activation in the right insula is associated with the initial detection of arousing emotional images and then subsequent activation is more specifically associated with processing disgust (Chen et al., 2009).

A number of more recent studies have specifically focussed on the functional activation associated with disgust rather than the activation differentiating the basic emotions. While many neural regions have been implicated in disgust processing such as the amygdala (Schienle, Schäfer, Walter, Stark, & Vaitl, 2005), orbitofrontal cortex and occipital lobe (Schienle, Schäfer, Stark, Walter, & Vaitl, 2005), as well as the right putamen (Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998) and the basal ganglia (Calder et al., 2001), disgust is most consistently associated with insula activation in the literature. Insula activation has been observed in response to disgusting scene images (Klucken et al., 2012; Schienle et al., 2002; Wright, He, Shapira, Goodman, & Liu, 2004) as well as facial expressions (Calder et al., 2001; Jabbi, Bastiaansen, & Keysers, 2008; Phillips et al., 1997; Sprengelmeyer et al., 1998) and dynamic videos (Harrison, Gray, Gianaros, & Critchley, 2010); disgust induced through inhaled odorants has also been associated with similar levels of anterior insula activation to that of viewing disgusted facial expressions (Wicker et al., 2003). Activity in the insula, recorded through intracerebral Event Related Potential (ERP) recordings, has revealed that the anterior insula does seem to be more active in processing disgust than other facial expressions, but only at certain post-stimulus periods (roughly 300-500 ms), and spiking sooner when emotional appraisal is explicitly directed (Krolak-Salmon et al., 2003).

Most studies finding insula activation use visual stimuli, but it has been found that when pure disgust is evoked through written sentences insula activity may not be increased (Moll et al., 2005). This finding led the authors to speculate that more *abstract* pure disgust is less salient than direct sensory exposure to disgust; however, it is difficult to reconcile this suggestion with the finding in the study that sociomoral indignation (a more abstract process) *was* associated with increased insula activation (though Moll et al., speculate that this could be a result of sociomoral indignation being more "deeply ingrained in its structure", p. 76). However, another study using written stimuli also failed to find increased insula activity for core disgust (Schaich Borg, Lieberman, & Kiehl, 2008) so it does seem possible that insula activation for pure disgust is contingent on the disgust being evoked through direct sensory processing. In general, sociomoral disgust has been found to share a considerable overlap in neural activation with physical disgust; however, these studies have also found that sociomoral disgust is associated with increased activation in the orbitofrontal cortex, dorsolateral prefrontal cortex and bilateral temporal gyrus (Moll et al., 2005; Schaich Borg et al., 2008), thus supporting the intersecting appraisal systems proposed by Chapman and Anderson (2013). Within the non-moral disgust domains, differences in neural activation have been found between viewing images evocative of core (i.e. oral) disgust and animal reminder disgust (as conceptualised by Rozin et al., 2000), with core showing increased activation in the medial temporal gyrus and the occipitotemporal cortex relative to animal reminder disgust (Borg, de Jong, Renken, & Georgiadis, 2012). This study also revealed increased insula activity as a function of disgust sensitivity (a finding discussed in more detail in chapter two), thus illustrating the significance of the insula to various components of disgust.

Confirmation of the insula's importance to disgust can be found in studies where damage to the insula appears to be associated with deficits in disgust processing (Adolphs, Tranel, Koenigs, & Damasio, 2005; Calder, Keane, Manes, Antoun, & Young, 2000). The level of insula atrophy in patients with Huntington's disease has been found to be related to reductions in disgust facial recognition (Kipps, Duggins, McCusker, & Calder, 2007). Huntington's disease in general is associated with disgust processing deficits (Calder et al., 2001; Hayes, Stevenson, & Coltheart, 2007; Sprengelmeyer et al., 1996, 1997), though other findings suggest that the neurological deterioration associated with the disorder can also result in deficits with the recognition of other emotions (de Gelder, Van den Stock, de Diego Balaguer, & Bachoud-Lévi, 2008; Johnson et al., 2007; Milders, Crawford, Lamb, & Simpson, 2003). There is some evidence that impairments associated with disgust recognition in Huntington's patients are revealed only in the domain of core disgust (Calder et al., 2010); though there is also evidence that deficits beyond actual recognition can be observed, and that Huntington's disease can affect semantic knowledge of disgust (Hayes, Stevenson, & Coltheart, 2009). The widespread neural deterioration that results from Huntington's disease is associated with impacts on numerous functions and it is clear that it can affect the recognition of numerous emotions; however, central to the notion that the insula is heavily implicated in disgust processing, it does also appear to be the case that the insula damage suffered as a result of the condition is correlated with disgust processing deficits.

The insula is clearly a versatile neural structure active in circuits that support numerous functions including the processing of other emotions such as anger (Damasio et al., 2000) and fear (Schienle et al., 2002); however, activity in this region is certainly strongly, although not exclusively, related to disgust processing. For a multitude of disgust recognition and processing tasks, activation is most consistently observed in parts of the insula (particularly the anterior insula) and deficits in this area (through neurological disorders or otherwise) are associated with deficits in disgust processing. Though, it serves more general functions in emotion processing, it does appear as though activation within a certain post-stimulus onset time period is strongly associated with processing disgusting entities in the environment, and to date the insula is the most researched neural structure associated with disgust and it appears to facilitate aspects of disgust processing across numerous subdomains of the emotion.

1.5. Disgust in Development and Implications for Standard Disgust Theories

A great deal of research on disgust within psychology appears to be set within the broader conceptualisation of emotions as discreet universal functional programs (following the traditions of Darwin and Ekman); possibly as a result of this approach, much research is concerned with identifying the function of the emotion, examining the qualities of specific elicitors that provoke its manifestation, and with identifying the structure of the neural architecture associated with these functions. To date, there has not been a great deal of research on the development of disgust in children and this may be partially a result of the way in which the literature on the subject has developed over time. Most of this section discusses the research of Widen and Russell (particularly Widen & Russell, 2013), which has challenged the *standard* account of disgust (that it is as an evolved universal signal).

Widen and Russell (2013) highlight the failure to consistently observe the standard disgust expression among participants who have been exposed to disgust – for example, they describe how Reisenzein (2007) only found a disgust expression 29% of the time following reports of high levels of subjective disgust experience – as a problem for theories emphasising the role of the disgusted face as an automatic signalling tool. This low coherence between the disgust expression and the subjective experience of disgust has also been found in a subsequent review by Reisenzein, Studtmann, & Horstmann (2013). Broader problems with forced choice response tasks (where participants' tendency to select an appropriate disgust response to visual stimuli vary as a function of the responses available) are also discussed, as are the methodological problems with the original cross-cultural research on basic emotions. The inconsistency with which many research paradigms provoke disgust response options or (more problematically) disgusted behavioural responses (such as expressions) demonstrate that there exists substantial difficulties with disgust elicitation and recognition even in western adult populations.

Research on children would appear to be even more problematic for the standard disgust account, particularly for theories that represent disgust as a functional behavioural program that should emerge intact holistically rather than emerging from the development of other functions. Research on infants seems to suggest that infants are not repelled by disgusting objects (such as faeces) in the way that adults, or older children, are (Rozin, Hammer, Oster, Horowitz, & Marmora, 1986) and produce a facial expression recognisable as disgust in response to elicitors that are not disgusting (Bennett, Bendersky, & Lewis, 2002; Rosenstein & Oster, 1988). Further, an understanding of *contamination* related disgust (being disgusted by an object due to its prior contact with a disgust elicitor) appears to emerge in children between 3-5 years old (Raman & Gelman, 2008) or even older (Fallon, Rozin, & Oliner, 1984). Children also show a reduced propensity to attribute the word *disgust* to violations in the moral domain compared to adults (Danovitch & Bloom, 2009), preferring instead to use the label of anger (Pochedly & Zeman, 2012, as cited by Widen & Russell, 2013) – a finding that supports the notion that a process of learning is necessary to associate the language of disgust with the moral domain (and also supporting the view of Royzman et al., 2014, that anger is the emotion that is more readily associated with moral violations). Regarding anger, research suggests that children have great difficulty distinguishing between disgusted and angry expressions even up to the age of eight (Widen & Naab, 2012; Widen & Russell, 2002, 2008a, 2008b). This inability amounts to a tendency to describe classical disgusted expressions as *angry* more often than *disgusted*, rather than reflecting the (comparatively) lesser perceptual difficulties adults experience due to the overlap between the similar structural elements present in angry and disgusted expressions (Pell & Richards, 2011, 2013; Skinner & Benton, 2010). Clearly the evidence supports the notion that children do not respond to disgust elicitors in the same way that adults do, and do not use the disgusted facial expression to specifically signal a disgust elicitor or even necessarily recognise it as a signifier of disgust.

Widen and Russell (2013) propose that the standard developmental trajectory is that infants initially differentiate simply on the grounds of valence and then gradually develop the ability to discriminate within valence categories. Under this account, young infants interpret disgust as anger and over development learn to associate disgust elicitors with the disgusted facial expression and eventually (over the age of nine) come to differentiate disgust from other negative emotions. Initially, disgust is experienced by children as a general unhappiness (Widen & Russell, 2008b) that comes to be coupled with an elicitor and later associated with the disgust lexicon (and even later with the facial expression). This development is proposed to be generally reflected over different cultures but over discrepant time periods (for example French children are more likely to recognise the standard disgust face as disgusted before the age of nine than American children – Izard, 1971) and is dependent on exposure to particular learning experiences and cultural experiences (that teach the individual to associate disgust signals or terms with particular elicitors sooner). Widen and Russell (2013) suggest that the disgusted facial expression can therefore be serve the function of being a *sign* rather than a universal *signal* of disgust, and that some experience with seeing this expression in others, associating it with disgust, and then miming it, is necessary before an individual can use it as a disgust signalling social communication tool themselves. This process of developing a disgusted expression as a signalling tool is one that tends to frequently occur over development, thus leading to the perceived universality of disgust related behaviour.

Clearly research into infants and children presents substantial problems for theories that represent disgust as a discrete universal signal inexorably linked to the standard facial expression and not being decomposable into constituent or precursory elements or (even partially) a product of culture or early environment. However, research paradigms that represent disgust as a discrete basic emotion (including forced choice response tasks of various kinds) are still extremely valuable to understanding disgust (and other emotions) as they still examine an extremely reliably observed and referred to emotional state in adults that is described (whether a result of evolution, development, or culture) in terms of being a discrete and highly specific psychological experience. Utilisation of such psychological research paradigms does not require an adherence to the notion that basic emotions are non-overlapping or universal, but merely an understanding of what the results signify and how to best place them in the context of the literature.

This chapter has provided an overview of disgust and how it is currently conceptualised and represented in the psychological literature. Many important research areas that have enlightened our understanding of disgust were not included here but are included in subsequent chapters. The next chapter will focus on the broad issue of *trait disgust* as it is an extremely important topic to the research presented in this thesis. Likewise, chapter three deals with the broad topic of *disgust exposure* (i.e. the tendency for exposure to disgusting stimuli to influence aspects of subsequent behaviour and cognition) as it is the specific area that the research presented here focuses on.

Chapter 2. Trait Disgust: Measures and Outcomes

2.1. Overview and Introduction

Chapter one discussed the numerous approaches that have been taken to conceptualising the dimensions of disgust; unsurprisingly, given these multiple approaches, there have also been numerous proposed measures that have attempted to reveal the individual differences that exist within the population across these various subdimensions of disgust. There are currently several *disgust sensitivity* measures that see consistent use in the literature with each attempting to capture unique individual variability across several domains. This chapter will provide a discussion of the most consistently used measures, focussing on how each one has delineated disgust, and how the scales have been used in disgust research. Despite the radically discrepant approaches to conceptualising disgust that these measures (explicitly or implicitly) entail, the usefulness of each scale is closely related to the particular area under investigation; for example, though there is clear dispute about whether the aversive experience triggered by moral indignation is best represented as disgust, it may still be useful to employ a disgust sensitivity questionnaire which incorporates a moral dimension when studying individual differences in moral judgement. Possibly because of this pragmatic approach, questionnaires that conceive of disgust in discrepant ways are often utilised even within the same study.

This chapter will discuss only the disgust sensitivity tools that attempt to provide a comprehensive map of general disgust among the general population; several shorter and more specific disgust sensitivity questionnaires exist for very specific assessments of aspects of disgust (often for specific groups of individuals) but will not be dealt with in detail in this chapter. For example, principles underpinning existing disgust questionnaires have been adapted and revised to construct distinct scales for use among non-English speaking groups – most notably the Scale for the Assessment of Disgust Sensitivity (SADS), which draws on the work of Cavanagh and Davey (2000; see chapter 2.5) in assessing the level of emotional intensity associated with disgusting experiences for German speaking participants (Schienle, Dietmaier, Ille, & Leutgeb, 2010). Scales have also been constructed that attempt to measure highly specific psychological variables associated with disgust – such as the fear of spiders (Armfield & Mattiske, 1996; Szymanski & O’Donohue, 1995) and blood-injuries (Merckelbach, Muris, de Jong, & de Jongh, 1999) in individuals with phobias, and the general contamination cognitions found in preclinical OCD sufferers (Deacon & Maack, 2008; Deacon & Olatunji, 2007). Outside of psychopathology, questionnaires have also been designed to examine the specific disgust related beliefs held by children towards animals (Muris, Mayer, Huijding & Konings, 2008; adapted by Askew, Çakir, Põldsam, & Reynolds, 2014), a scale later expanded into the DES-C (Disgust Emotion Scale for Children) which also measured children's disgust for elicitors in other domains (Muris et al., 2012). Questionnaires on specific aspects of disgust have also been constructed for highly specific research purposes, such as self-disgust (Overton, Markland, Bagshaw, & Simpson, 2008), sexual disgust (van Overveld et al., 2013), and a questionnaire specifically assessing the cognitive (rather than affective) components of disgust (Teachman & Saporito, 2009). However, these scales either do not attempt to quantify the dimensions of general disgust, have a very specific (sometimes diagnostic) utility, or are used very infrequently in the literature.

Along with discussing the various scales that have been proposed to measure disgust sensitivity, this chapter will also discuss the cognitive and behavioural variables that appear to be influenced by individual differences in disgust sensitivity across its variously proposed subdomains. Evidence for the potential neuroanatomical mechanisms that appear to underpin differences in disgust sensitivity (based on the limited research that is currently available) will also be examined. An assessment of the theoretical basis of each of the questionnaires and their relative merits (for the research this thesis is concerned with) formed the basis of the selection of the trait disgust measurement tool utilised in the research work presented in this thesis (see chapter 4.6.1 for the questionnaires that were included).

2.2. The Disgust Contamination Questionnaire

The Disgust Contamination Questionnaire (DQ; Rozin, Fallon, & Mandell, 1984) is an attempt to assess contamination sensitivity. It evaluates individuals' inclination to avoid eating food items that have been contaminated in some way by a disgust elicitor (such as a fly) and is assumed to provide an assessment of an individual's behavioural response to contamination fears. This scale has been used on some research on phobias where contamination is a central component (de Jong & Merckelbach, 1998; Matchett & Davey, 1991; Merckelbach, de Jong, Arntz, & Schouten, 1993). Using this scale, it has been found that although disgust sensitivity did not appear to be related to a range of psychopathological conditions (such as anxiety, depression and eating disorders) as had been previously speculated (Phillips, Senior, Fahy, & David, 1998), it was related to OCD and phobias (Muris et al., 2000). These remain the most common areas of psychopathology studied using disgust sensitivity measures (see chapter 2.3).

More recent disgust scales extend beyond contamination aversion questions and represent disgust sensitivity across multiple domains of elicitor. Many of these more recent scales also include contamination sensitivity as a subdomain (see chapter 2.7); as a result, these more general scales tend to be used in recent research that seeks to explore contamination aversion. Aspects of the DQ were adapted for the next scale described.

2.3. The Disgust Scale

Perhaps the most commonly used disgust sensitivity assessment (at least in its revised form – see chapter 2.7) is the Disgust Scale (DS; Haidt et al., 1994). This scale is based on the earlier DQ and represents disgust sensitivity across seven domains of elicitors (food, animals, body products, sex, body envelope violations, death and hygiene). Although moderate intercorrelations were observed between domains, the authors of the questionnaire concluded that there was sufficient domain specificity for these domains to be represented as subdomains of a central disgust construct. Haidt et al. (1994) suggested that these multiple domains may have specific utility to different areas of research and that they represented the range of elicitors that were capable of generating a physical disgust response. Attempts to behaviourally validate this scale (i.e. derive correlations between questionnaire scores for each domain and of actual avoidance behaviour for each elicitor type in the DS) have only met with moderate success (Rozin, Haidt, McCauley, Dunlop, & Ashmore, 1999), though when the subdomain scores were totalled into an overall marker of disgust sensitivity this study did find that the scale predicted disgust-motivated avoidance behaviour.

This scale has been used in several areas of research. As with the DQ, the DS has been used persistently in phobias research, particularly with research into animal phobias where high DS scores are associated with phobias for typically disgust evoking invertebrates (such as insects, molluscs and spiders) and for small animals commonly repellent to phobics (such as rats) but not for larger more threatening animals (such as tigers, bears and sharks; Matchett & Davey, 1991). As with the DQ, high disgust responses in the DS are commonly associated with spider fears in particular (de Jong, Andrea, & Muris, 1997), though there is also evidence that disgust is a significant factor in snake anxiety (Klieger & Siejak, 1997). The various subdomains that compose the DS enable researchers to test whether these common disgust sensitivity effects are a result of sensitivity to a specific aspect of disgust. Research on these subdomains has suggested that animal reminder disgust is the specific variable that drives the enhancement of disgust sensitivity in individuals with spider phobias (de Jong & Merckelbach, 1998).

However, subsequent research on the DS subdomains has provided less intuitive results – with findings indicating that sensitivity to the domains of animal, death and body envelope are higher in individuals with injection and spider phobias than non-phobics, and that injection phobics are also more sensitive to other domains such as body products or sex (Sawchuk, Lohr, Tolin, Lee, & Kleinknecht, 2000). The elevation of disgust sensitivity for domains of disgust unrelated to the phobia, and the fact that phobia-specific elicitors on the DS did not differentiate between the two phobic groups, led the authors of this study to conclude that disgust sensitivity may be a more general construct rather than being highly elicitor specific (a view discussed in more detail in chapter 2.7). It is also important to note that although phobia of a specific elicitor is associated with an unpleasant response to that elicitor, that response need not necessarily be a result of feeling disgusted; Tolin, Lohr, Sawchuk, and Lee (1997) indicated that while injection phobias were associated with increased disgust for phobia-specific elicitors, the aversive response experienced by spider phobics was one born predominantly of fear (with disgust a comparable but lesser component). In contrast, however, it has been found that spider phobia is primarily driven by assessments of disgust (de Jong & Muris, 2002), so whether or not disgust is the primary evoked emotion, it does appear to play a significant role in phobias of this type. Clearly, although the DS lends itself to phobia research – due to the highly domain specific nature of phobias and the ability for the DS to target these elicitors easily –, domain specific disgust sensitivity does not necessarily appear to be the primary cause of phobias (or at least not of specific phobias). There does however appear to be a consistent finding across these studies that, although analysis of domain specific disgust can produce some difficult to interpret results, more general disgust sensitivity summed across the DS domains does appear to be heightened in individuals with phobias and this is even reflected in behavioural avoidance measures (Mulkens, de Jong, & Merckelbach, 1996). This relationship between disgust sensitivity assessed by the DS and phobias appears to manifest particularly for variants of animal phobias

The other main area in which the DS has been used is in Obsessive Compulsive Disorder (OCD) research. It has been found that, after controlling for age, sex, anxiety and depression, disgust sensitivity correlates with OCD symptoms (Mancini, Gragnani, & D'Olimpio, 2001). Other studies have also found a similar association (Thorpe, Patel, & Simonds, 2003; Woody & Tolin, 2002) and it has been speculated to be especially pronounced amongst OCD sufferers with contamination and washing concerns (Berle & Phillips, 2006; Schienle, Stark, Walter, & Vaitl, 2003) who appear to experience contamination related fears for objects that have previously interacted with, but are now far removed from, sources of contagion (Tolin, Worhunsky, & Maltby, 2004). The inclination to engage with contaminated objects appears to be strongly related to disgust sensitivity assessed through the DS – which has been found to moderate the relationship between an individual's tendency to overestimate contamination consequences and their resulting anxiety towards and avoidance of objects perceived as contaminated (Deacon & Olatunji, 2007). Fear of contamination, particularly as it manifests in individuals with OCD, seems to be a psychological construct related to broad generalised disgust, rather than showing a great deal of specificity for subdomains of the DS – although it does appear to be more strongly related to items that pertain to contagion (Olatunji, Sawchuk, Lohr, & de Jong, 2004). The DS has therefore been of great utility in highlighting disgust as an extremely important variable in some forms of OCD, as well as highlighting the strong relationship that exists between disgust and contamination fears.

The DS has been used less in research on behavioural outcomes and cognitive processing, but it has been used successfully to demonstrate how disgust sensitivity is accompanied by a reduced ability to disengage attention from disgusting objects in the environment (Cisler, Olatunji, Lohr, & Williams, 2009; see chapter 3 for a more in-depth review of this literature). It has also been found that higher scores in the contamination subscale are associated with lower incidence of recent infection – thus serving as a protective factor against contaminants (Stevenson, Case, & Oaten, 2009). Typically the DS tends to be used to obtain a general marker of participants' disgust sensitivity rather than being broken into subdomains. It is still not entirely clear whether individuals do show meaningful variability across domains (and if they do, to what extent) or whether questions pertaining to specific disgust elicitors simply provide a weaker assessment of general disgust sensitivity; bifactor models of disgust sensitivity (see chapter 2.7) may provide a greater insight into this issue. The DS is also rooted in a particular conception of disgust, and central concepts to this formulation (in particular the sub domains representative of animal reminder elicitors) have been criticised (see chapter 1.3.1). However, the DS does remain an effective marker of global disgust sensitivity with a number of utilities (particularly with relation to phobias and obsessive behaviours); this core questionnaire was later modified by Olatunji et al. (2007; see chapter 2.7) and this revised form is an extremely popular disgust sensitivity assessment tool that is used frequently in modern disgust research.

2.4. The Disgust Emotion Scale

The Disgust Emotion Scale (DES; Walls & Kleinknecht, 1996) was primarily constructed for use in specific phobias research but covers as wide a range of subdomains as other more general scales. The DES measures disgust at the thought of exposure to five domains of elicitors (animals, injections, mutilation and death, rotting foods and smells, thus overlapping with the DS on a number of domains). As with other disgust questionnaires, when a broad summed disgust measure is derived the scale is a useful predictor of phobias such as injection (Page, 2003). As with the DS, the subdomains of the DES have been revealed to show less specificity for phobias (Sawchuk et al., 2000) and contamination fears (Olatunji et al., 2004) than may be intuitively expected (for example, Sawchuk et al. found that disgust for rotting foods and smells were elevated in individuals with blood injection injury phobias along with the expected injection disgust). Despite the increase in global disgust sensitivity for individuals with specific phobias or contamination fears, these studies do also appear to demonstrate a further increase in disgust for elicitors in domains relevant to the disorder. Thus, as with the DS, the subdomains of the DES have shown some degree of utility and it is also a comparatively useful tool to the DS for the purposes of deriving a global marker of an individual's disgust sensitivity. However, possibly as a result of the overlap with the domains of the DS, the DES is used very infrequently in research – with the DS (original and revised) being a far more commonly utilised questionnaire. It is also worth noting that the dimensions of the DES have been found to be unreliable after controlling for a general disgust factor in a bifactor model (Olatunji, Ebesutani, & Reise, 2015; see chapter 2.7 and 2.8 for discussions of bifactor models for other disgust questionnaires).

2.5. The Disgust Propensity and Sensitivity Scale Revised

The original Disgust Propensity and Sensitivity Scale (DPSS; Cavanagh & Davey, 2000) and the revised version (DPSS-R; van Overveld, de Jong, Peters, Cavanagh, & Davey, 2006) use a different approach to conceptualising disgust sensitivity than the previously described scales. The central premise of the theory underpinning this scale is that previous disgust sensitivity questionnaires tend to evaluate the mere likelihood of an individual becoming disgusted (and thus attributing the label of *disgust* more frequently to a set of elicitors or situations) – a concept better conceptualised as disgust *propensity* rather than *sensitivity*. In contrast, disgust *sensitivity* is argued to be better represented as the psychological unpleasantness actually experienced by an individual when they are feeling disgusted. Disgust sensitivity is a variable that is argued to, at least to some extent, vary independently from propensity as individuals may differ in how they respond to disgusting stimuli while still abstractly identifying the same set of stimuli to be disgusting. Hypothetically, the differences in sensitivity would reflect the actual negativity associated with disgust, and propensity would merely provide a marker for how likely a particular elicitor is to be labelled as disgusting. Under this model, most previous disgust questionnaires are speculated to not capture the actual emotional negativity that an individual experiences when they feel disgusted, thus potentially neglecting the most important aspect of disgust as a psychological experience.

In the original revised questionnaire article (van Overveld et al., 2006), the authors demonstrated that disgust propensity alone was a significant predictor of spider phobias, whereas sensitivity and propensity were both predictors of blood injury phobias. The former of these findings was speculated to be a result of spider phobias being more dependent on fear than disgust, thus provoking individuals to use the disgust label but not resulting in the visceral sensations specifically associated with being disgusted. Blood injury phobia, on the other hand, is predominantly associated with the sensation of disgust (Page, 1994, 2003; Tolin et al., 1997). These findings, along with a confirmatory factor analysis that yielded a two factor model, led van Overveld et al. to conclude that disgust propensity and sensitivity are separable constructs with different and specific predictive capability when related to other psychological factors.

As with earlier questionnaires, the DPSS-R has been used in the study of OCD, with research suggesting that disgust propensity is associated with OCD washing behaviours and avoidance of contact with disgusting material, whereas disgust sensitivity appears to be more related to general emotional sensitivity (Goetz, Lee, Cougle, & Turkel, 2013; Olatunji, Moretz, et al., 2010). Given that the theory underpinning the DPSS-R suggests that previous disgust questionnaires have been assessments of propensity rather than sensitivity, and given that these previous questionnaires have also been used extensively in OCD research, it is perhaps not surprising that it is the propensity subscale that appears to be most systematically related to behaviours associated with the condition; however, it is worth noting that individuals with OCD appear to have heightened disgust sensitivity as well (Whitton, Henry, & Grisham, 2015), and there is evidence that suggests that the tendency to overestimate the consequences of contamination is related to disgust sensitivity rather than propensity (Mitte, 2008). The importance of disgust propensity has been underlined in studies suggesting that disgust propensity (assessed through the DPSS-R) moderates the relationship between obsessive beliefs and contamination fears (Cisler, Brady, Olatunji, & Lohr, 2010). However, despite these promising findings on the relationship between disgust propensity and OCD, it is worth noting that disgust propensity is heightened to comparable levels in individuals with generalised anxiety disorder (GAD; Olatunji, Wolitzky-Taylor, et al., 2010) and that levels of self-disgust may be a more potent predictor of OCD (at least for contamination based varieties) than disgust assessed through the DPSS-R (Badour, Bown, Adams, Bunaciu, & Feldner, 2012). Thus, although disgust propensity is a useful marker of OCD, it is also a marker of other psychological disorders and may not be the aspect of disgust that is most important in predicting OCD behaviours.

Badour et al. (2012) also found that disgust sensitivity (but not propensity) correlated with posttraumatic stress symptoms (amongst women who had previously experienced physical or sexual assault), and examination of this relationship between disgust sensitivity and posttraumatic stress is a fairly new area of research that has nonetheless produced some promising findings. Research on posttraumatic stress disorder (PTSD) among soldiers returning from Afghanistan suggests that disgust propensity was a predictor of peritraumatic disgust (measured as the disgust experienced at the time of a soldier's most negative traumatic event) – a variable which predicted the severity of PTSD symptoms after 6 months; disgust sensitivity, on the other hand, was found to moderate the relationship between peritraumatic disgust and PTSD such that its increase was reflected in increased symptom severity (Engelhard, Olatunji, & de Jong, 2011). In another study of PTSD amongst sexual assault survivors, it was proposed that *mental contamination* (defined as feelings of internal dirtiness after the event) was the factor that linked disgust sensitivity and posttraumatic stress, with individuals high in disgust sensitivity experiencing a greater degree of mental contamination after the event thus prolonging and worsening posttraumatic symptoms (Badour, Feldner, Blumenthal, & Bujarski, 2013). Subsequently, it was argued that self-focussed (rather than perpetrator focussed) disgust was a highly important variable in mental contamination following sexual assault, but that general disgust propensity remained an important predictor (Badour, Ojserkis, McKay, & Feldner, 2014). Although several studies have found a relationship between disgust and posttraumatic stress among a clinical sample, other studies have failed to find correlation between disgust and posttraumatic stress amongst undergraduates high in posttraumatic stress (Ojserkis et al., 2014). Regardless of the nature of the relationship between disgust sensitivity, disgust propensity and posttraumatic stress, the distinction between propensity and sensitivity has proved to be useful in illuminating the topic.

Perhaps due to the emphasis on visceral sensation for the sensitivity subscale (or alternatively as a result of the expansion of disgust research since the original paper was published), the DPSS-R has been used in studies examining behaviours which have a strong physiological component. Emetophobia (fear of vomiting) manifests in sufferers as an intense fear of vomiting themselves or of seeing others vomit, as well as of vomiting in public (Lipsitz, Fyer, Paterniti, & Klein, 2001; Veale & Lambrou, 2006; van Hout & Bouman, 2012); given that vomiting is strongly associated with disgust (see chapter one), the hypothesis that the strong aversive sensation experienced by emetophobics would be related to disgust sensitivity is an intuitive one. Research using the DPSS-R has demonstrated that emetophobics do indeed have elevated levels of both disgust sensitivity and propensity (van Overveld, de Jong, Peters, van Hout, & Bouman, 2008; Boschen, Veale, Ellison, & Reddell, 2013) and tend to overestimate the possibility of threat and illness based on experienced disgust (Verwoerd, van Hout, & de Jong, 2016). Similarly to emetophobia, exploring disgust sensitivity and propensity in the context of taste and digestion appears to be a pertinent and cogent line of research. In this vein, research suggests that taste sensitivity is related to disgust propensity but not sensitivity (or measures of moral disgust; Herz, 2011) and that some symptoms of eating disorders are related to propensity but not sensitivity (Chu, Bodell, Ribeiro, & Joiner, 2015). Disgust propensity is also associated with more reluctance to engage with disgusting (including sexually disgusting) tasks (Borg & de Jong, 2012; though this experiment did not analyze disgust sensitivity results).

The distinction between disgust sensitivity and propensity is one that has proved useful in multiple lines of research and the DPSS-R is highly predictive of disgust avoidance (van Overveld, de Jong, & Peters, 2010). Although the subscale scores within the DPSS-R are often highly correlated, and many studies fail to find independent predictive capability of propensity and sensitivity (or use only one of the subscales), research has yielded sufficiently promising results for the dissociation to be worthwhile for many hypotheses. The preponderance of research would seem to suggest that although propensity and sensitivity often covary with respect to certain variables, there may be specific areas (such as posttraumatic stress) where the visceral emotional response to disgust (i.e. the psychological construct tapped by disgust sensitivity) is a much more relevant variable. There is evidence that high levels of propensity and sensitivity actively modulate different neural areas (Borg et al., 2012), but this is discussed in more detail in chapter 2.10. There is also evidence that disgust propensity (in particular) is changeable in the short-term as a result of emotional experience (Viar-Paxton & Olatunji, 2012; though this study did not examine such changes in disgust sensitivity), a finding that will be discussed in more depth in chapter 2.11. Given the argument by van Overveld et al. (2006) that previous self-described "disgust sensitivity" questionnaires were in fact better conceptualised as *disgust propensity* measures, and to avoid terminology confusion, the remainder of this thesis will refer to these other questionnaires as measures of disgust propensity (with *disgust sensitivity* being used to refer to the construct identified by van Overveld et al. and described in this section), regardless of how it is labelled within the actual studies.

2.6. The Questionnaire for the Assessment of Disgust Sensitivity

The Questionnaire for the Assessment of Disgust Sensitivity (QADS; Schienle, Walter, Stark, & Vaitl, 2002) was originally constructed as a German translation from the original DS but assessed across a consistent five-point response scale; however, the questionnaire was also revised to include additional items relating to deformation before being further refined to include the principal five factors of death/deformation, body secretions, spoilage, poor hygiene and oral rejection (see Petrowski et al., 2010 for an overview of the original construction of this questionnaire). Petrowski et al. reassessed the factor structure of this questionnaire and reconstructed the items of the scale to more parsimoniously represent the factors of core disgust, animal reminder disgust and contamination disgust. These three identified subscales correspond to those represented in the revised version of the disgust scale (see chapter 2.7) and Petrowski argues that rather than simply being a translation, the additional items in the QADS results in a revised version that is more reliable than the original QADS or the original or revised disgust scales (with Cronbach's alpha being around of .90 for each of the three factors).

Possibly resulting from its inception as a translation of the original disgust scale and its subdomain overlap with the extremely prevalent revised disgust scale (in Petrowski's reworking), the QADS is used relatively infrequently in research (though the revised version of the QADS has existed for less time than the more commonly used scales). The original version of the QADS was typically used in research on German participants, sometimes as an assessment of OCD and control samples (e.g. Schienle et al., 2005) or as a tool for matching participants in between-subject conditioning paradigms (Klucken et al., 2012 – this study is discussed more in chapter three). Although there is overlap in domains with the next questionnaire to be discussed, the fact that the identified factors in the revised version of the QADS so closely mirror this conceptualisation (in a data driven study with a large, heterogeneous and representative sample) undoubtedly lends credence to the formulation of disgust propensity conceptualised across the domains of core, animal reminder and contamination disgust.

2.7. The Disgust Scale Revised

The original DS was an extremely popular tool for assessing disgust propensity despite the subscales having fairly low internal consistency (Haidt et al., 1994). In order to address this, Olatunji and colleagues attempted to reassess the latent structure of the DS and refine the complete set of items to remove those with low internal consistency; the resulting 25 item questionnaire assessed the dimensions of core disgust, animal reminder disgust and contamination disgust and showed much higher internal consistency (Olatunji et al., 2007). This revised disgust scale (DS-R) has been used persistently in many areas of research and this conceptualisation of the latent psychological factors contributing to disgust propensity has been useful in a variety of research areas. As with the DPSS-R, the DS-R focuses on physical responses to disgust (rather than attempting to determine aspects of moral disgust sensitivity as other questionnaires have done), and although animal reminder disgust is a theoretical concept that has met with some criticism (see chapter 1.3.1), the emphasis in the questionnaire on the disgust experienced in reference to biological processes makes this questionnaire a particularly relevant measurement tool for research concerned with correlates of the various aspects of physical disgust (or even just as a control between experimental groups). This questionnaire also appears to be the one most commonly utilised in lab-based psychological experimentation (as opposed to psychometric or personality research), perhaps because much of this research is focussed on examining the observable behaviour associated with physical disgust, and the scenarios depicted in the items of the DS-R are particularly relevant for this.

An initial exploration of the validity and applicability of the DS-R revealed that the three subscales appear to be correlated with neuroticism and inhibition; further, visual avoidance and physiological responsiveness to videos associated with each type of disgust were most strongly (though not exclusively) correlated with the relevant subscale score; finally each subscale score was associated with a different pattern of relations to particular fears and phobias (e.g. animal and blood injection) and contributed significant unique variance to assessing repugnance towards these stimuli (Olatunji et al., 2008). The authors conclude that correlations with core disgust (particularly behavioural avoidance of disgusting scenarios related to oral consumption and vomit) support the notion that core disgust motivates caution against consumption of potential contaminants (Rozin & Fallon, 1987). Animal reminder disgust as a unique form of disgust governed by defence of body abnormalities and threat to bodily wellbeing is argued to be supported by associations between this factor and the avoidance of surgery videos as well as correlations with blood injection phobias. Contamination disgust was found to be associated with avoidance of potentially harmful contaminants and predicted contamination-based OCD – and was speculated to be evolutionarily adapted from core disgust to extend the avoidance characteristics associated with core disgust with contamination threats to the body outside of oral incorporation. The DS-R appears to have improved internal consistency and predictive capability compared to the original DS (van Overveld, de Jong, Peters, & Schouten, 2011) and the dimensions of the DS-R have also proven to be relatively stable across samples from multiple continents (Olatunji et al., 2009). However, amongst adolescent samples it appears as though the items of the questionnaires load onto factors better described as contagion, mortality and contact disgust, which, while distinct from the original three factors in the DS-R, are argued to be conceptually similar with item loadings overlapping considerably with the three factors in adult samples (Kim, Ebesutani, Young, & Olatunji, 2013). The domains of the DS-R appear to also be systematically related to genes associated with dopamine receptors (Kang, Kim, Namkoong, & An, 2010).

Subsequent research has expanded upon the aversive behavioural response component of Olatunji et al. (2008). Research using a conditioning paradigm has found that high disgust propensity (assessed through the DS-R), but not trait anxiety, is associated with increases in disgust, anger and anxiety for a word paired with unpleasant images (Olatunji, Tomarken, & Puncochar, 2013). Using a similar paradigm, it has also been found that higher DS-R scores are associated with increased avoidance of disgusting unconditioned stimuli but only when subjective disgust of such stimuli is high (Armstrong, McClenahan, Kittle, & Olatunji, 2014; this article is discussed in greater detail in chapter 3.4.2). Contamination disgust has been revealed to be a particularly good predictor of actual behavioural avoidance of disgusting material, though all three factors appear to be associated with self-reported contamination anxiety (Olatunji, Ebesutani, Haidt, & Sawchuk, 2014). It is worth noting that research does not support the notion that there is a discrete taxonomic aversive personality type despite it being a component of many anxiety related disorders (Olatunji & Broman-Fulks, 2009). It is also worth noting that although research on aversive behaviours suggests that disgust propensity can seemingly serve as a protective factor immunising the individual from excessive exposure to stimuli that is potentially harmful or psychologically troubling, research using the DS-R has also highlighted the ways in which high disgust propensity can also result in subsequent intrusive cognitions following such exposure (Bomyea & Amir, 2012) thus seemingly resulting in the opposite result. The DS-R has, nevertheless, assuredly revealed that there is a strong link between disgust propensity and aversion (both self-reported and experimentally observed).

One recent area of research that has utilised the DS-R is in the study of eating habits and disorders. This research clearly demonstrates that disgust propensity is a predictor of eating habits – thus supporting the notion that one of the core functions of disgust is to inhibit consumption (see chapter 1.3). Core disgust and contamination disgust appear to be associated with less restraint in eating and, consequently, higher body mass index (Houben & Havermans, 2012). Eating habits and willingness to consume unfamiliar foods also appear to become more restrained as animal reminder disgust increases (Hamerman, 2016). Given the relationship between disgust propensity and broad eating behaviour it is not surprising that disgust propensity assessed through the DS-R is found to be in higher in individuals with anorexia nervosa (as can be seen in the samples prior to manipulation in Fox et al., 2013). Eating behaviours and attitudes have therefore been found to be related to all three domains of the DS-R across different studies (chapters five and seven explores associations between disgust and food in more detail).

Many uncovered associations between the DS-R scales and particular outcomes are consistent with the mechanisms of the proposed latent psychological variables represented by the three domains of the DS-R; however, there does appear to be a degree of overlap between these types of disgust with regard to the behavioural responses they are speculated to underpin. For example, along with evoking core disgust, vomiting should also serve as a reminder of the animal nature of the individual and in some circumstances should also carry the threat of viral contamination – so could potentially be expected to be associated with all three types of disgust in the DS-R rather than being more specifically related to core disgust (as was found in Olatunji et al. (2008). Likewise, the threat of blood-borne disease could be hypothesised to be associated with fear of potential blood contaminants and contamination disgust, rather than solely stimulating animal reminder disgust. It is not currently clear why these outcomes are related to specific domains of the DS-R and not others, and although potential evolutionary mechanisms could be proposed to account for these differences, the soundness of these hypotheses would be difficult to establish. If post hoc explanations can easily be generated to explain the relationship between each of the specific subdomains and a particular outcome (that is to say that a particular outcome being associated with any specific subdomain, but not the others, has negligible implications for the theory underlying the model) then it may call into question the utility of the subdomains as a predictive tool.

Regardless of these theoretical issues, the domains of the DS-R clearly appear to provide unique predictive capability for particular behavioural and personality variables and are domains of disgust relevant to many areas of research.

The DS-R has been used to support a bifactor model of disgust, with the suggestion that disgust propensity is better represented by a model with a broad general disgust dimension that underlies all the items of the DS-R, and the three other dimensions in the questionnaire (core, animal reminder and contamination) accounting for unique variance over and above the main factor (Olatunji, Ebesutani, Haidt, & Sawchuk, 2014). This study demonstrated a better fit for such a bifactor model and presented evidence that contamination anxiety is predicted by the three additional domains above general disgust, but that only animal reminder disgust predicts non-contamination anxiety (more general trait anxiety for perceiving threatening or stressful situations) and that only contamination disgust predicts behavioural avoidance of disgusting stimuli. This bifactor model may be promising for helping to explain why disgust subscale scores that are not theoretically related to the outcome in question often correlate with these outcomes in experimental research.

The DS-R is among the most commonly used disgust propensity measures in recent disgust research. Although the relationship between the latent psychological constructs that are represented by the three domains and the variety of outcomes they are associated with are not thoroughly understood, and although the domains themselves have been criticised on theoretical grounds (particularly animal reminder disgust), the three domains represented by the DS-R have shown more predictive utility and internal reliability than many of the other disgust propensity measurements and it seems to be a very useful tool in experimental research.

2.8. The Three Domain Disgust Scale

The final questionnaire discussed here is the Three Domain Disgust Scale (TDDS; Tybur, Lieberman, & Griskevicius, 2009) which breaks down disgust into pathogen, sexual and moral domains. This questionnaire is grounded in an evolutionary account of disgust postulating that sexual and moral disgust emerged after pathogen disgust as a result of a co-opting of the existing physical disgust architecture to provide an adaptive benefit in the social domain – an account described in Tybur et al. (2013; see chapters 1.3.2 and 1.3.3 for a discussion of this theory). Regardless of the criticisms of moral disgust as a concept that actually reflects the same psychological state as physical disgust, the moral subscale of the TDDS does seemingly provide an assessment of the concept readily referred to (in English speaking countries) as *moral disgust*. The original TDDS paper (Tybur et al., 2009) does clearly provide support for pathogen, sexual and moral disgust being distinct personality variables (though this would still be the case if the sexual and moral factors did not actually represent disgust). This study also illustrates that the three subscales were correlated (thus potentially, though not conclusively, bolstering the claim that these three factors are all under the same broad emotional umbrella). It is also important to note that the authors of the TDDS argue that pathogen disgust is identical to the disgust represented by the *behavioural immune system* hypothesis (Schaller & Duncan, 2007) both functionally and computationally (Lieberman & Patrick, 2014) thus potentially providing converging evidence for an evolutionarily grounded form of physical disgust.

Strong evidence for the coalescence of the three subdomains of the TDDS comes from a quantitative genetics study that found considerable heritability for each of the three subtypes of disgust along with a general disgust genetic factor underlying the subdomains (Sherlock, Zietsch, Tybur, & Jern, 2016). The bifactor fit of the TDDS, with such an underlying disgust factor, has been examined by Olatunji, Ebesutani, and Kim (2015). This study found a good fit for the bifactor model but found that only the moral dimension contributed significant unique variance above the main factor (with the sexual and pathogen domains being more related to generalised disgust) thus leading to the conclusion that it may be best to use a general disgust score rather than the sexual or pathogen subscales. These results could suggest that the moral disgust subscale is actually representing a psychological variable distinct from the disgust that is captured by the items that load onto the pathogen and sexual disgust scales. Indeed, Olatunji et al. (2012) found that moral disgust in the TDDS reflected attitudes more related to *harm* and *care* (concepts relating to the virtue of *kindness*) rather than attitudes of *purity* and *sanctity* typically referenced in cases where moral disgust is reported. The approach of Tybur et al. has also been criticised on the grounds that it ignores cultural evolution and conceptualises disgust overly narrowly as a result (Rozin & Haidt, 2013). However, given that moral disgust is a concept that is still subject to considerable theoretical debate (much of which concerns whether it actually reflects the emotion of disgust at all), it is difficult to contemplate a measurement of the concept that would be theoretically parsimonious with the existing literature.

Due to the inclusion of a moral subscale, the TDDS has been regularly used in research into morality and politics, and the consistent correlation with these behavioural and personality measures provides support for the predictive capability of the moral subscale (whether it reflects disgust or not). Given that research of this nature has also utilised the other disgust scales (as researchers are often also concerned with the relationship between specifically *physical* disgust and moral beliefs), a discussion of the relationship between disgust propensity and morality is contained in the next section (chapter 2.9) and includes studies utilising the other questionnaires discussed in this chapter.

Outside the moral domain, the TDDS has been used (presumably as a result of the inclusion of a sexual disgust scale) to explore the relationship between sexual attraction and disgust. These results show, perhaps unintuitively, that higher pathogen (rather than sexual or moral) disgust is associated with a reduced attractiveness towards lower attractive faces amongst men and women (Park, van Leeuwen, & Stephen, 2012) and stronger negative attitudes towards obese individuals, and increased preference for healthy characteristics amongst men (Fisher, Finch, Hahn, DeBruine, & Jones, 2013) – a claim also supported by research suggesting that pathogen disgust is associated with a preference for a narrower waist amongst men (Lee, Brooks, Potter, & Zietsch, 2015). Although this preference for characteristics associated with increased health was prevalent amongst men but not women, studies using female samples have also revealed a stronger preference for enhanced masculinity among women with higher pathogen disgust for facial features (DeBruine, Jones, Tybur, Lieberman, & Griskevicius, 2010) as well as voices and bodies (Jones et al., 2012). Sexual disgust on the other hand appears to be associated with mating strategy – with proclivity for uncommitted short-term relationships being associated with lower levels of sexual disgust (Al-Shawaf, Lewis, & Buss, 2015). Thus, using the conceptual ideas in the theory outlined by Tybur et al. (2013), pathogen disgust appears to motivate mate selection in a similar way to sexual disgust – with disease and pathogen avoidance being an important aspect of such a preference as well as the *genetic compatibility* and *mate quality* assessment function that is guided by sexual disgust. However, given that sexual disgust is speculated to be an evolved function for assessing potential partners, it is not clear why some of this selection criteria is necessarily tied to the more phylogenetically ancient form of pathogen disgust (and then only through the *association* between attractiveness variables and health related risks); further, it is difficult to conceive of these multiple forms of disgust working in parallel within the same cognitive architecture to sum together to produce these assessments. It is possible that future research will provide more clarity as to the contributions of the various domains of disgust on mate selection, but regardless of this the TDDS has undoubtedly been an extremely important tool in developing this area of research.

The potential conceptual limitations of the TDDS are still a subject of debate, but the domains represented by the scale make it a useful tool for researchers concerned with attractiveness, sexual preference and the various aspects of moral beliefs. For research more concerned with physical disgust elicitors, other questionnaires may be more relevant.

2.9. Disgust Propensity and Political Beliefs

Given that disgust has been hypothesised to be evoked as a result of moral assessments (see chapter 1.3.3), the relationship between long-term moral preferences and disgust propensity has been an area that has been subject to a large amount of research in recent years. This relationship appears to manifest most clearly in studies that have explored the link between disgust propensity and political affiliation and belief. Most of the research in this area has used broad disgust propensity measures that average across subdomains (and thus can be assumed to reflect generalised rather than specific disgust); as a result, and given the likely capability of all the commonly used disgust propensity measures to successfully approximate this underlying factor, the specific questionnaires used in these studies will not be reported in this section (aside from cases where findings are relevant to a specific questionnaire subdomain).

The most replicable finding on this topic is that there appears to be a positive correlation between disgust propensity and self-reported conservative political attitude (Inbar, Pizarro, & Bloom, 2009; Terrizzi, Shook, & McDaniel, 2013), which reflects actual voting habits (Inbar, Pizarro, Iyer, & Haidt, 2012). Most of this research has been conducted on U.S. samples; however, the relationship between disgust propensity and morality has also been observed in European samples (Brenner & Inbar, 2015). This general relationship has been speculated to reflect an association between disgust sensitivity and specifically *socially* conservative values regarding intergroup dynamics (Terrizzi, Shook, & Ventis, 2010). Evidence suggests that the mechanism underpinning this relationship may be an unwillingness in conservatives (relative to liberals) to reappraise their initial disgust reaction in response to moral social issues – with conservatives even showing similar support for same sex marriage as liberals after an instruction to reappraise their initial emotional reaction (Feinberg, Willer, Antonenko, Horberg, & John, 2014). Recent research has also begun to explore the notion that this effect is moderated specifically by sexual disgust (as measured by the subscale of the TDDS) and is generally reflective of the propensity towards monogamy and of mitigating the risks of pathogens transmitted through sexual contact (Tybur, Inbar, Güler, & Molho, 2015; Tybur, Merriman, Hooper, McDonald, & Navarrete, 2010;); the role of religiosity, along with sexual ideology, has also been found to play a moderating role (Olatunji, 2008). This account of sexual disgust as a moderating factor is certainly bolstered by previous studies that have highlighted the strong link between disgust propensity and sexual morality specifically (Crawford, Inbar, & Maloney, 2014).

The preponderance of this research concerns the relationship between disgust propensity and specifically conservative political beliefs; however, research has also suggested that disgust propensity may be associated with other political affiliations. Disgust propensity has been found to be correlated with more traditionally liberal (at least in the U.S. population) causes such as animal welfare activism (Herzog & Golden, 2009). The authors of this study speculate that this could suggest that disgust propensity motivates moral activism more generally; however, it is also possible to speculate that issues such as animal welfare are likely to involve psychological engagement with physically disgusting material (such as animal corpses) which could generate a greater negative affective response (and thus subsequent engagement with activism) in individuals more sensitive to disgust. An exploration of the link between liberal causes that do not involve physically disgusting material would be necessary to explore this association further. There is also some evidence that inducing disgust can lead to an increased affirmation of left wing economic principles, but this effect may be bound with individual differences in body consciousness (Petrescu & Parkinson, 2014). Among U.S. samples, self-described political libertarianism is associated with lower levels of disgust propensity, but this appears to be in conjunction with being less emotionally reactive overall compared to liberals or conservatives and may also be driven by the increased number of males who self-describe as libertarian (Iyer, Koleva, Graham, Ditto, & Haidt, 2012).

This research on disgust propensity among liberals and libertarians could indicate that a tendency towards intense emotional response to social issues could facilitate higher disgust propensity, though the direction of causality could just as easily be speculated to run counter to this. More research into the correlates of disgust propensity in individuals who do not identify as conservatives, but who are high in disgust propensity, would be useful in illuminating the link between disgust and politics. Currently the vast majority of the research is concerned with the link between disgust propensity and conservatism, and the findings do appear to be robust and replicable and have contributed significantly to our understanding of the individual differences in disgust propensity and the factors that are affected by this measure.

2.10. Neural Correlates of Disgust Propensity and Sensitivity

Many studies have examined the pattern of functional activation associated with the experience of disgust (see chapter 1.4), but research examining the ways in which individual differences in both disgust propensity and sensitivity influence this activation is lacking. Possibly the most influential study in the area is by Borg et al. (2012) and used the DPSS-R to examine the influence of both disgust propensity and sensitivity on the processing of stimuli associated with core or animal reminder disgust. The results revealed that disgust sensitivity (but not propensity) augmented the insula's response to core and animal reminder disgust, whereas disgust propensity correlated with the coupling between activation the right ventrolateral occipitotemporal cortex and the anterior cingulated cortex (particularly for animal reminder stimuli). This inhibitory effect of disgust propensity is speculated to serve the function of "safeguarding" the individual from experiencing animal reminder disgust. This suggests that disgust sensitivity modulates the initial detection (and experience) of disgusting stimuli and propensity is associated with the streamlining and further processing of this information. This builds on earlier work that suggested that core and animal reminder (or more specifically: "body boundary violation") disgust are separable in fMRI data and that insula activation correlates with subjective disgust assessment (Harrison et al., 2010).

Another key study directly assessing the neural correlates of trait disgust measures is by Scharmüller and Schienle (2012). This study assessed gray matter volume in key regions associated with disgust processing (the insula and relevant areas of the prefrontal cortex) and whether this systematically varied with levels of disgust propensity (measured using the QADS). The results revealed that grey matter volume in the right insula was positively correlated with individual differences in the *oral rejection* subscale of the questionnaire; further, the *death* and *decay* subscales (subscales containing items similar to those that comprise the animal reminder disgust subscale of DS-R) were negatively correlated with activity in prefrontal regions. The latter finding is interpreted as evidence for a lack of cognitive control capacity (limited by the lower grey matter volume) in highly disgust prone individuals that inhibits emotion regulation – thus leading to a reduced ability to manage their aversive response to such unpleasant stimuli. One limitation that this study has (with regard to how much it reveals about disgust) is that in examining correlations between disgust and stable anatomical measures (with no cognitive task) it is not possible to test whether this grey matter volume specifically influences disgust processing rather than emotion processing more broadly. It is also not possible to infer whether propensity measures for other emotions are also associated with such grey matter correlates. It is entirely possible, given the data, that these correlations merely reflect emotional reactivity and control more broadly.

The final study discussed here is a very recent experiment that builds on the latter one by examining the associations between disgust sensitivity (as assessed through the SADS in a female German sample), rather than propensity, and grey matter volume in key regions associated with emotion processing (Wabnegger, Übel, & Schienle, 2017). This study found that disgust sensitivity correlated positively with grey matter volume in the left orbitofrontal cortex but negatively with the left medial frontal cortex. Though it is difficult to infer the significance of grey matter volume levels in these regions (as they are regions associated with numerous specific processes, many of which could be relevant), the authors speculate (based on inferences from prior findings on the processes associated with these regions' activations) that the increased volume in the orbitofrontal cortices of highly disgust sensitive individuals could reflect increased feelings of shame and embarrassment when responding with disgusted reactions in public, or alternatively could reflect greater negative emotionality more broadly. The reduced grey matter volume in the left medial frontal cortex for highly disgust sensitive individuals is speculated to reflect their reduced ability to exert sufficient cognitive control to down-regulate negative emotional response.

Regardless of potential problems with extrapolating beyond the data set, the results of these three trait disgust correlational studies do appear to align and suggest that core and animal reminder disgust (both in trait measures and in actual neural responses to stimuli emblemising these categories) are subject to differential contributions from neural structures associated with disgust more broadly. These studies would suggest that core disgust is associated predominantly with insula activation, whereas animal reminder disgust draws in regions from the broader emotion processing network. Further, disgust sensitivity is associated with modulation of the insula whereas propensity facilitates the coupling between the insula and cortical regions. Finally, grey matter volume measures that are concordant with differences in ability to facilitate these processes are also observed and appear to be related to differences in self-reported disgust propensity (for the relevant subdomains) and sensitivity. More research is needed to fully explore the mechanisms by which disgust propensity and sensitivity exert an influence on an individual's ability to process disgusting information, but the research does appear to indicate that neural correlates of these measures are readily detected in typical functional and anatomical imaging paradigms and that these trait measures likely exercise a substantial influence in neural processing of disgusting stimuli.

2.11. Disgust Propensity Changes Over Time

Although disgust propensity is regarded as relatively stable personality trait, albeit one that is believed to decline with age (Curtis, Aunger, & Rabie, 2004; Fessler & Navarrete, 2003; Quingley, Sherman, & Sherman, 1996), some studies have found that certain experimental manipulations have the ability to alter participant responses to these measures in the (relatively) short-term. Over a six month period, disgust propensity (assessed through the DES) was found to reduce slightly among individuals with OCD symptoms (Berle et al., 2012). Some repeated measure studies involving an emotional manipulation have also found changes over a much smaller time period. Viar-Paxton and Olatunji (2012) revealed that the disgust propensity subscale of the DPSS-R was increased after a one week interval following repeated exposure to disgusting videos. In addition, over the same time period (one week), it has also been found that increased engagement with health related behaviours has the capacity to increase disgust propensity (Olatunji, 2015). Over a much shorter time period (e.g. over the course of a single session experiment), disgust propensity (assessed through repeated completions of the DS-R) has also been found to be increased as a result of an emotion inducing manipulation among anorexics (but not amongst control participants; Fox et al., 2013).

Studies have also found that disgust propensity responses are influenced by short-term changes to other internal and external events. Increased stress and hunger appears to be associated with higher disgust propensity scores (Al-Shawaf & Lewis, 2013), and disgust propensity has also been speculated to be increased as a result of the recency of infectious disease (Stevenson et al., 2009). These latter two correlational studies do demonstrate that the reportedly stable disgust propensity trait correlates with traits that are known to be variable over time; however, the lack of repeated measures (of disgust propensity) in these studies makes this interpretation more tenuous and other interpretations possible. For example, participants who report increased hunger levels could represent individuals with greater moment-to-moment body consciousness – a variable that, given the proposed nature of disgust as a bodily protective mechanism, could be associated with disgust propensity. Stevenson et al. (2009) make a compelling case for the interpretation that frequency of illness increases contamination disgust, but repeated measures of disgust sensitivity would certainly go a long way to confirming this interpretation as there are other possible post hoc interpretations of their data that do not necessitate levels of disgust changing.

Disgust propensity measures have been shown to be relatively stable over time in the absence of an experimental intervention (Olatunji & Cisler, 2009; van Overveld et al., 2006), but it is clear that it is possible to alter responses to these questionnaires as a result of emotional exposure (a concept discussed more broadly in chapter three) in the short-term. It is not clear over what time period following these changes that disgust propensity returns to baseline (assuming it does at all), but it does appear to be possible for experimenters to alter the results of these questionnaires as a result of commonly used manipulations. It is worth noting that many of these studies that have revealed disgust propensity changes have used populations with anxiety related disorders (such as anorexia and OCD), and it is possible that the lower levels of emotional regulation typically associated with these disorders leads to a more pronounced effect from short-term emotional influences such that it can influence disgust propensity. Consistent with this, the Fox et al. (2013) study found that disgust propensity measures were consistent before and after emotional exposure amongst the control participants. It is worth noting that all these studies have used measures of disgust propensity and it is not clear whether this trait is more prone to instability (following emotional manipulations) than disgust sensitivity measures. It is also worth noting that many cognitive psychology studies that have employed emotional manipulations of this nature – but have taken disgust propensity measures *after* exposure (de Jong et al., 1997) – have not found that these manipulations were associated with disgust propensity differences. It seems there is insufficient evidence to conclude that the potential instability of disgust propensity presents a particular problem for experimental research on non-clinical participants. However, the potential instability of disgust propensity, and the conditions under which individual scores can change at different measurement times, is a subject worth investigating further as it will almost certainly contribute significantly to our understanding of how disgust propensity functions.

This chapter has presented an overview of the conceptual underpinnings of all the major disgust propensity and sensitivity questionnaires as well as their major research utility and personality and psychopathological correlates. This chapter has also outlined the (limited) research that has been conducted on the neural mechanisms regulated by disgust propensity and sensitivity and what they have suggested about the neuropsychological functions of these variables. The selection of the trait disgust measurement tools used in the experimental research in this thesis is discussed in chapter four (along with an explanation for all the other initial methodological decisions) but with reference to the theoretical discussions of the questionnaires found in this chapter.

Chapter 3. The Consequences of Disgust Exposure

3.1. Overview of this Chapter

So far this thesis has discussed aspects of disgust that relate to its function, the ways in which it operates neuropsychologically, and the extent to which individuals differ in their capacity to experience (and label their experience as) disgust. This chapter is concerned with the *influence* of disgust and how the experience of disgust affects other aspects of behaviour and cognition. More specifically, this chapter is concerned with how exposure to disgusting information affects other psychological and behavioural outcomes. In order to discuss this, it is necessary to first provide a (briefer) summary of how emotional content (of both positive and negative valence) more broadly has the capacity to influence subsequent processes. After this broader introduction, this chapter will present an overview of the significant body of literature that has explored the ways in which exposure to disgust influences moral judgement and decision making (thus drawing upon the moral disgust theory outlined in chapter 1.3.3). One of the most influential areas of modern disgust research (along with the findings relating sensitivity and propensity to psychopathology and political affiliation) lies in paradigms that have induced disgust in individuals and found that this influences moral decision making in the short-term. Although morality is not the focus of this thesis, a great deal of research that has induced disgust has been in this field so it is necessary to discuss this literature when discussing the dynamics and consequences of disgust exposure. The final part of this chapter will explore the literature on which the experimental research work in this thesis is primarily based – mainly the influence of disgust exposure on short-term perceptual processing. Given the large body of research concerned with the influence of disgust exposure on behavioural and self-report outcomes (outcomes that occur after processing), exploring the time-course dynamics by which disgust exposure actually influences the ways in which information from the environment is processed has the potential to contribute greatly to our understanding of how disgust operates and, more broadly, how decoding emotional information in the environment can be affected by contextual factors (including those that operate on levels outside of conscious experience).

3.2. An Introduction to Emotional Exposure

Research on emotional exposure (as it is conceptualised in this chapter) encompasses a broad range of research paradigms and response measures. Emotional exposure research is taken to mean any research concerned with the ways in which emotional information, that is not directly related to the outcome measure of the task (that is to say that it is not task relevant), influences said outcome measure. The form in which this incidental emotional information is presented and the outcome measures differ considerably across the research presented in this chapter. Regarding the emotional exposure itself, the research discussed in this chapter can broadly be subdivided into research where the exposure occurs *prior* to the outcome measure (for example, a paradigm where participants read an emotionally provocative story and then complete a cognitive task) and research where the exposure occurs *simultaneously* with the outcome measure (for example, a paradigm where participants have to identify targets presented against a background that is emotionally provocative). Given the discrepant contribution that cognitive variables such as visual attention and emotional regulation likely have on these different forms of emotional exposure (with regard to preventing such exposure from influencing task performance), it is likely that the form in which the exposure takes place is influential on the outcome variable. Another important distinction concerns whether the outcome variable is related to emotion processing (i.e. examining whether emotional exposure biases perception and processing of emotional stimuli) or to more general cognitive and behavioural tasks (such as the moral decision making tasks reported in chapter 3.3). The research presented in this chapter will include paradigms utilising both of these emotion exposure strategies and outcomes related both to emotion processing and to processing more generally.

3.2.1. Mood related effects.

One way in which emotional exposure has been studied is in the context of mood related effects. In psychology, moods have been defined as a "relatively low-intensity, diffuse, subconscious, and enduring affective states that have no salient antecedent cause and therefore little cognitive content" (Forgas, 2006, p. 6-7; Forgas & Koch, 2013). Given that many of the earliest studies that are cited to provide evidence of mood related effects involve inducing mood through such consciously unpleasant manipulations as electric shocks (e.g. Feshbach & Singer, 1957), it is difficult to understand in what way mood is a phenomenon with no salient antecedent cause. It seems that although mood can be an affective state that can be experienced in the absence of a consciously accessible antecedent cause, there are times where the cause of mood is very well known to the individual (such as the lingering negative mood experienced following receiving bad news).

A slightly different account of mood is from Ekman (1984) who emphasised the demarcation between emotions and moods and speculated that moods resulted from changes to the biochemical state in the individual (as a result of influences such as tiredness and diet) and that these changes could be generated through repeated elicitations of particular emotions over a short period (such as repeatedly feeling anger leading to an irritable mood). Ekman suggested that moods have the potential to alter the frequency, duration and intensity of emotional events (such that, for example, an irritable person becomes angry more frequently, for a longer duration, and with increased intensity). This theory would seemingly imply that emotions and mood effectively perpetuate themselves and enhance each other in a feedback loop (though this is not stated directly) – as negative moods should increase incidences of negative emotions, which, in turn, should increases the tendency to be in a negative mood. Clearly under this account of mood, one of the defining features is its ability to alter subsequent emotional experience – thus resulting in the prediction that mood should affect emotional processing in psychological experiments (assuming the research tools are sufficiently sensitive to detect such changes). In line with this, Forgas (2006) has noted that mood researchers are typically concerned with "the cognitive and behavioural *consequences* of these affective states" (p. 7).

As with many aspects of affective experience, it is difficult to define what a mood is, but clearly one of the defining characteristics is that it has the potential to influence subsequent emotional behaviour. Because of this, studies that attempt to manipulate participants' ongoing affective disposition through sustained or intense exposure to negative or positive emotional stimuli are regarded as mood manipulation studies for the purposes of this chapter. As a result, many of the studies referenced in subsequent sections are considered to be mood manipulations even if not directly referred to as such.

Early studies utilising mood manipulations indicated that inducing negative mood through a variety of mechanisms (including aversive smells, electric shocks and classical conditioning) appears to negatively alter participants' evaluations of sociopolitical messages (Razran, 1940) and also of individuals (Clore & Byrne, 1974; Feshbach & Singer, 1957). Assessments of ambiguous visual stimuli (such as pictures and word stems) appear to be strongly influenced by mood – with happy participants generating far more positive assessments (Bower, 1981). More recent research has demonstrated that both day-to-day positive mood and mood induced through a positive mood manipulation (recalling positive life events) is associated with greater attention to positive rewarding words (such as "reward", "fun" and "pleasure") in a spatial probe task (Tamir & Robinson, 2007). Inducing mood through providing participants with chocolate has also been found to be associated with attentional preference for positive images (Wadlinger & Isaacowitz, 2006). Both positive and negative mood (induced through recalling life events) are associated with increased awareness for positive and negative faces respectively in an inattentional blindness task (Becker & Leinenger, 2011). Thus, through a variety of cognitive psychology paradigms, mood has been revealed to have a congruent influence on attention towards positive and negative emotional information.

These mood related congruence effects have also been observed in studies examining social judgement and behaviour. It has been found that inducing this negative mood (through exposure to sad documentaries) is associated with increased scepticism towards the motives of others and increased assessments of guilt (towards individuals accused of stealing) from facial cues (Forgas & East, 2008). This manipulation has also been found to influence politeness in verbal requests (Forgas, 1999). Inducing a negative mood through false feedback on verbal ability task performance has been shown to influence performance in a strategic social negotiation task – with more cooperative strategies employed by those experiencing positive feedback and more competitive strategies by those experiencing negative feedback (Forgas, 1998a). These mood related interpersonal effects have also been found to have an effect in a real world setting, where it has been found that exposure to negative pictures (car accidents left on a desk) influenced librarians' compliance with a subsequent request (Forgas, 1998b). It appears as though these real world mood related effects may extend to stereotyping, where it has been found that a happy mood is associated with an increased predilection towards forming evaluations based on stereotypes (Bodenhausen, Kramer, & Süsser, 1994; Forgas, 2011; Unkelbach, Forgas, & Denson, 2008) and it has been argued that this is a result of positive moods biasing processing strategies towards more top-down heuristics (Bless & Fiedler, 2006). It is clear that as well as influencing processing, mood manipulations have the capacity to influence interpersonal social assessments and behaviour and that they exert an influence in the same mood congruent direction as they do in cognitive experiments. This has been found to have consequences in real world settings as well as controlled lab environments.

One seemingly intractable confound that persists (and may be unavoidable) in studies that have *manipulated* mood (rather than studies that have examined mood through self-report) and examined its effects on subsequent emotion processing (rather than other cognitive outcomes) is that it is very difficult to determine whether effects from such manipulations are a result of mood per se or whether they simply reflect emotional congruence priming on a conscious level (that is, whether their effects result from the actual affective experience of being in a particular mood, or from the prior semantic activation of emotional categories). It may even be that such semantic priming is one of the primary mechanisms by which mood influences cognition. However, regardless of the potential mechanisms, mood does clearly have the potential to influence emotional processing and behaviour, and is clearly an example of consequential conscious emotional exposure (unlike more subliminal priming paradigms that function on an implicit level).

3.2.2. Subliminal and supraliminal priming with emotion.

Experiments that have used mood manipulations to explore emotion are attempting to directly assess the consequences of the conscious psychological experience of emotion. Other cognitive psychology paradigms are less concerned with the conscious *affective* experience generated through emotional exposure, but are instead concerned with the extent to which semantic information about emotional categories is accessed during such exposure, and the extent to which this semantic activation can bias subsequent processing and emotional assessments. It has long been known that emotional content (particularly of faces) can be processed even when attention is diverted to another task (Eastwood, Smilek, & Merikle, 2003) and that physiological responses to emotional stimuli can be generated even when the emotion is not consciously processed (Esteves, Dimberg, & Öhman, 1994). Research suggests that negative emotions, in particular, are difficult to disengage from once they are perceived (Fox, Russo, Bowles, & Dutton, 2001) and this difficulty is sustained even with schematic facial representations (Blagrove & Watson, 2010; Watson & Blagrove, 2012). There is a wide array of experimental paradigms that utilise emotions (with both facial expressions and other stimuli) to capture attention or disrupt processing in this way. Subliminal priming paradigms explore the dynamics of emotional perception by (typically) presenting participants with a very brief (usually 50 ms or less) masked emotional image and then assessing whether this affects the reaction time to, or emotional classification of, a subsequent emotional target image. This examines the extent to which perceptual exposure to particular emotions can alter the processing of subsequent emotional stimuli even if the prime is not consciously perceived. This research paradigm has been used for decades in cognitive psychology with the earliest studies indicating that exposure to happy facial expressions can increase favourability towards an otherwise ambiguous stimulus (Murphy & Zajonc, 1993), as can exposure to positive or negative prime words (Greenwald, Klinger, & Schuh, 1995). The brief emotional prime images are typically not identifiable by participants (Greenwald et al., 1995), but activate neural regions associated with the processing of these emotions (Morris, Ohman, & Dolan, 1998;

Whalen et al., 1998) thus suggesting that emotional discrimination is occurring below the level of conscious awareness. While the conscious and non-conscious emotional perception mechanisms that visual priming paradigms stimulate do appear to diverge somewhat along cortical and subcortical pathways, it has been proposed that conscious emotional perception is actually reliant on an integration of both pathways and thus partially depends on non-conscious perceptual mechanisms (Tamietto & de Gelder, 2010). In light of this, although studies distinguish between subliminal and supraliminal priming, these systems may not function as fully discrete processes.

Most research on subliminal priming has used facial expressions as the primes, which allows for an alternative explanation for non-conscious priming effects. According to the motor mimicry account (Yang & Tong, 2010), expressions bias responses primarily through sensorimotor, rather than semantic, priming (that is to say that they increase low level motor activation of facial areas that then biases responses towards that particular emotion). However, recent research using briefly presented photographs that provoke emotional reactions, rather than facial expressions, would seem to preclude this account as it has been found that brief primes consisting of fear inducing or disgust inducing photographs bias responses to subsequent photographs of the same emotional category but do not share structural elements and should not stimulate motor areas (Neumann & Lozo, 2012). This study demonstrated that responses to photographic images used as targets could be influenced by primes consisting of emotional photographs, faces and words thus suggesting that it is the semantic information about the emotional category that is significant in these priming paradigms. It is also worth noting that simultaneous pairing of a target and a prime from different stimulus categories (e.g. an emotional expression against an emotional background photograph) appears to also result in a congruence related processing benefit (Righart & de Gelder, 2008).

Other studies also appear to confirm the hypothesis that very brief subliminal primes have the capacity to bias processing beyond valence. Rohr, Degner, and Wentura (2012) discovered that very brief emotional expression primes (of between 14 and 33 ms) were sufficient to influence responses to facial expression and emotional word targets beyond mere valence categories. This study used a wider range of emotional categories than Neumann and Lozo (2012) did, and did not find that emotional targets were exclusively biased by emotional categories of the same type; rather, Rohr et al. (2012) found that priming occurred at the level of valence, as well as at the level of the behaviours associated with the emotion. Specifically, it was found that emotions associated with behavioural approach (anger and joy) and emotions associated with behavioural avoidance (fear and sadness) were able to exert an influence on targets of this same behavioural tendency. Effects related to the specific emotional category were not found. Thus, although both Rohr et al. (2012) and Neumann and Lozo (2012) found priming effects beyond valence, the category in which these effects were found to manifest was different. Given that these two studies used discrepant stimuli, emotional categories, and presentation times, it is possible that numerous structural or emotional influences produced the discrepancies in results.

Subsequent research by Rohr and Wentura (2014) illuminates these findings further and does appear to find priming effects at the level of the specific emotion (within highly specific parameters). In a series of studies using spatially filtered facial expressions, emotion specific priming effects emerged with primes that were fully visible and consciously processed. With truly subliminal primes, it was found that emotion discrimination occurred within the negative emotional category only amongst low spatial frequency filtered stimuli (i.e. stimuli where only broad facial configurations were discernible). With these stimuli it was found anger and fear could be differentiated from sadness but not from each other (a finding interpreted as distinguishing between high and low arousing emotions). Valence effects only emerged from high spatial frequency filtered stimuli (where more specific emotional features are visible). This study indicated that priming effects that reduced down entirely to the level of the specific emotional category required the primes to be extended and consciously processed (thus representing supraliminal primes). High or low spatial filtering appears only to exert an influence in priming on stimuli that are not consciously processed; further, in implicit processing, valence information appears to be contingent on processing of high spatial frequency information whereas discrimination within the negative group is contingent on low spatial information. It remains unclear as to whether these subliminal priming effects are truly occurring at the level of emotional arousal or the behavioural tendencies associated with the emotion as the influential studies in this area have used such widely discrepant stimuli and also discrepant presentation times and SOAs – factors known to be extremely important in influencing the dynamics of priming effects (Greenwald, Draine, & Abrams, 1996). Even if the exact level at which these effects operate remains slightly unclear, there does seem to be ample evidence to suggest that discrimination beyond mere valence is occurring at a subliminal level.

Evidence for the effects of supraliminal priming (priming where the prime stimuli are fully consciously processed) appears to be much clearer. Rohr and Wentura (2014) clearly demonstrated that emotion specific effects under conditions where the prime is consciously processed. Other studies have also demonstrated emotional valence congruence effects using paradigms where primes are fully processed. Rapid serial visualisation paradigms using ERP measures – experiments where emotion processing is assessed through averaged electrophysiological responses to supraliminal stimuli representing specific emotional categories (these paradigms, and ERP research in general, are discussed in more detail in chapter 4.2) – have revealed that electrophysiological markers indicative of early automatic emotion processing (see chapter 4.2.6 for details of this specific ERP component) are reduced when the previous picture is emotional, regardless of the emotional category of the target image (Flaisch, Junghöfer, Bradley, Schupp, & Lang, 2008). Subsequent research has also found that ERPs reflecting later more elaborative emotion processing (see chapter 4.2.8 for a discussion of this component) also show this reduction following emotional primes (Flaisch, Stockburger, & Schupp, 2008). While it is possible to hypothesise that this represents a habituation effect (with the population of neurons with the potential to fire to subsequent emotional images reduced over time), this is probably unlikely given that habituation effects within these paradigms appears to be minimal (Schupp, Stockburger, et al., 2006). Instead, the authors speculate that these findings reflect that emotional primes automatically consume attentional resources, which are then limited for the attention capture of a subsequent emotional image.

Given that priming (at least using subliminal methods) tends to result in more efficient processing of concordant targets (i.e. quicker response times to targets of the same valence or emotional category as the prime), it is difficult to interpret what these ERP changes reflect (in the absence of behavioural measures). However, it is clear that the emotion of the primes in these paradigms (whether subliminal or supraliminal) has a significant impact on the processing of a subsequent emotional target. The evidence for valence related congruence effects in priming is clear, and there is also a growing body of research suggesting that the specific emotional category of the prime (or if not the category themselves, aspects of them such as the different levels of arousal they generate or the behavioural tendencies they provoke) is also important in influencing processing of subsequent images.

3.2.3. Adaptation and emotion aftereffects.

One research paradigm that is similar to subliminal priming, in that it examines how prior exposure to particular emotions can influence subsequent emotional assessment, is emotional adaptation. Adaptation studies have a long history in psychophysics and can be conceptualised as studies where a perceptual bias towards a stimulus is induced through prolonged or repeated exposure to a different stimulus. Adaptation aftereffects are often observed using motion – where repeated exposure to a stimulus moving in one direction results in a stationary stimulus being perceived as moving in the opposite direction –, however, aftereffects are also studied using colours and orientation, and may have the function of optimising perception by maintaining efficient coding (see Thompson & Burr, 2009 for an overview of visual aftereffects research). The fact that aftereffects can be observed across many structural aspects of faces and also, pivotally, for facial identity itself (Clifford & Rhodes, 2005; Leopold, O'Toole, Vetter, & Blanz, 2001) opens up the possibility that emotional expressions can also produce these aftereffects.

Research examining emotional expression aftereffects typically uses a paradigm whereby ambiguous facial expressions are created artificially by morphing two expressions onto the same face (so that the resulting face has many of the features of both expressions) and then examining whether repeated exposure to expressions that wholly represent one of these emotions biases the emotional assessment of the ambiguous face. The earliest research that was conducted using variants of this paradigm appeared to confirm the hypothesis that adaptation does indeed occur for emotional expressions and appears to bias perception away from the expression that participants were exposed to (Fox & Barton, 2007) and this effect has been replicated using multiple variations on this paradigm (Campbell & Burke, 2009; Ellamil, Susskind, & Anderson, 2008; Vida & Mondloch, 2009). These findings have been extended by research that used *anti-expression* paradigm – where a prototypical basic emotion expression is created and then the anti-expression version (where the features are morphed to a point that is the opposite of the expression) is constructed from it. These anti-expression studies have found that adapting participants to a particular anti-expression results in a bias towards perception of that corresponding expression in an average face (Skinner & Benton, 2010, 2012). This is significant for emotion theory given that anti-expressions are unlikely to be meaningful to participants and the adaptation is not towards other emotional representations as it was in previous emotional adaptation studies. If emotions are neurally represented by holistic discrete categories (as Ekman and colleagues have argued – see chapter 1.2.1), rather than by a decomposable selection of structural and affective elements, then it could be argued that anti-expressions (the processing of which should not activate the neural representation of basic expression modules) should not have the capacity to bias the perception of subsequent *real* expressions.

These anti-expression studies also demonstrated that adaptation to an anti-expression is associated with perceptual biases towards emotions sharing structural elements with the corresponding expression – critically for the work in this thesis, anti-anger and anti-disgust both had the capacity to bias perception towards anger *and* disgust rather than exclusively to the specific corresponding emotion (Skinner & Benton, 2010). The structural overlap between disgust and anger has been explored in more detail in recent years, and while it appears as though substantial overlap exists, the relationship may be asymmetric – with adaptation to disgust and anger biasing perceptions away from anger, but disgust alone biasing perception away from disgust (Pell & Richards, 2011). This study also indicated that this overlap appears to be driven by the mouth region (as producing stimuli with the mouth covered substantially reduced this overlap effect) – a finding interpreted as evidence of the communicative features of expanded disgust (as described by Rozin et al., 1994 as hinging on an upper lip curl) driving the adaptation effect towards perception of angry expressions. It has also been found that this emotional overlap adaptation effect is substantially decreased when the identity of the adaptation and target faces are incongruent thus demonstrating the interdependence of these emotional expression processing and identity processing systems (Pell & Richards, 2013).

Adaptation paradigms have revealed much about the mechanisms underpinning emotional expression processing and the ways in which prior exposure to exemplars of a particular emotional category can bias perception away from that emotion. It is curious that subliminal priming studies tend to reveal an emotional congruent processing benefit as a result of prior emotional priming – where perception is biased *towards* subsequent targets of the same category –, whereas emotional adaptation studies find a perceptual bias *away* from that emotional category. In this regard, emotional adaptation findings are also different from the emotional congruence effects typically observed in mood manipulation studies. This may indicate that the duration of the prime is highly significant in influencing subsequent emotional perception and may further elucidate the differential subliminal and supraliminal effects observed in priming studies. Alternatively, the typically ambiguous nature of the target stimuli in adaptation studies could be driving this difference. There is also some recent research that highlights the importance of the range of stimuli within such emotional categorisation studies

– with findings suggesting that a nose wrinkle is interpreted as disgust only when included in a set that also includes angry scowls, but when the set does not include such angry expressions it is interpreted as anger instead (Pochedly, Widen, & Russell, 2012). It would seem as though forced choice emotional expression evaluation paradigms are subject to a wide range of cognitive and contextual influences and the processes that manifest in these studies are strongly contingent on the timings of the experiment and the balance within the overall set of stimuli.

Unlike with subliminal priming studies, emotional adaptation studies necessitate the use of facial expressions which limits their utility when examining affective evaluations beyond simple perceptual discrimination (between emotional categories). The differences in potential scope between paradigms that utilise emotional facial stimuli and those that use emotional photographs are discussed in more detail in chapter 4.3.1 (as is the neural overlap between anger and disgust). Other prevalent cognitive psychology paradigms also examine the influence of emotional exposure (for example emotional Stroop tasks or flanker tasks); however, these paradigms often use emotional stimuli because they are highly salient intrusive distracters that can influence the task difficulty, and are often more concerned with using these stimuli as a mechanism of examining attention or anxiety (and thus do not really directly study emotion processing per se). Thus, discussions of these emotional exposure studies are beyond the scope of this thesis. One paradigm that may be of relevance is the emotional oddball task; however, much of this research uses electrophysiological measures (and this has been used as a fundamental method for exploring the dynamics of emotional ERP components) and thus it is discussed in more detail in chapter four.

This chapter has thus far provided an overview of some of the major research areas that have examined the influence of emotional exposure on emotional assessment. The subsequent sections in this chapter will provide a more detailed assessment of the considerable amount of research that has been conducted to examine the influence of exposure to disgust specifically. The next major section will discuss the link between prior disgust exposure and moral judgement and the final section will discuss the research that has examined the way in which exposure to disgust has influenced subsequent perception.

3.3. The Influence of Disgust Exposure on Moral Judgement

Moral disgust is a growing but controversial research area (see chapter 1.3.3); the fact that the language of disgust is often utilised (amongst English speakers) to condemn moral transgressions makes it a very interesting concept that is still in need of further elucidation. However, the link between disgust and morality is not limited to language, and over the last decade there has been a great deal of research that has suggested that exposure to disgust influences moral assessment. The earliest studies in this area were conducted as part of the developing *social intuitionist* theory in moral psychology described by Haidt (2007). Drawing on earlier work that suggested that damage to areas of the prefrontal cortex could result in a reduced affective response to personal moral dilemmas while cognitive ability and the capacity to explicitly evaluate right and wrong remained intact (Damasio, 2003), part of this theory held that seemingly elaborative moral decisions were in fact guided by affect-laden intuitions that were then rationalised post hoc. Theories emphasising the primacy of affect in guiding behaviour have a long history in psychology (for example see Zajonc, 1984) and have been speculated to underlie many aspects of decision making (Damasio et al., 1991). With regard to moral decisions, it seems as though utilitarian and non-utilitarian moral decisions are driven by partially separable systems that can be selectively interfered with – with affect being primarily responsible for non-utilitarian assessments (Greene, Morelli, Lowenberg, Nystrom, & Cohen, 2008). An illustration of this social intuitionist model came from Wheatley and Haidt (2005) who conditioned feelings of disgust to neutral words (such as "take" and "often") using post-hypnotic suggestion; in line with their hypothesis, participants who had been conditioned provided moral condemnation towards characters in stories that did not include any apparent moral transgression (but that did include the conditioned words). Wheatley and Haidt (2005) expected that after failing to find a post hoc justification for the condemnation, these conditioned participants would override their affective responses and re-evaluate their initial assessments. However, many participants went on to confabulate seemingly incoherent justifications for their condemnation thus seeming to provide support for the social intuitionist model of morality. Beyond moral psychology, it also appeared to provide evidence for the notion that experiencing disgust could result in changes to moral assessment.

Since Wheatley and Haidt (2005), many studies have been published that have induced disgust (or provided participants with reminders of disgust and cleanliness) in numerous ways and appear to confirm the hypothesis that disgust can indeed influence moral judgement. One of the influential studies in the area conducted a series of experiments where disgust was induced in numerous ways (through smells, environment, recall of disgusting experiences and videos) and it was found that each method increased the severity of moral transgressions (Schnall, Haidt, Clore, & Jordan, 2008). This study also found that exposure to sadness manipulations (typical of those used in the mood manipulation studies discussed in chapter

3.2.1) did not result in these effects (thus indicating that exposure to negative emotion more generally was not a sufficient explanation for these effects). Importantly, this study also found that body consciousness (the ability to be conscious of one's own internal physical states) was a moderating factor in this relationship (such that only individuals with high body consciousness were susceptible to the manipulation effects). This latter effect is interesting as one important aspect of interoceptive sensitivity (the ability to detect and monitor one's own physiology) is the ability to judge the timing of one's own heartbeat – a factor known to be correlated with automatic emotion processing (Pollatos, Kirsch, & Schandry, 2005; Herbert, Pollatos, & Schandry, 2007). Clearly Schnall et al. (2008) provides evidence that inducing disgust through multiple sensory and cognitive methods is able to consistently influence moral judgement in a way that sadness cannot.

Horberg, Oveis, Keltner, and Cohen (2009) also demonstrated that disgust (induced through videos), but not sadness, was associated with moral condemnation. This study further suggested these disgust effects were specific to morality violations related to purity (as described by Rozin et al., 1999) but not justice or harm, and also suggested that trait disgust (but not anger or fear) was associated with increased condemnation of purity violations (in the absence of a disgust manipulation). This study suggested a degree of specificity within the moral domain that is consistent with prior research on emotion and morality (Greene et al., 2008). Research has also indicated that disgust manipulations (in the form of exposure to still photographs) have the capacity to increase condemnation of fairness violations in economic games (an effect that only holds when the game is played with other human participants rather than against a computer) over and above sadness manipulations (Moretti & di Pellegrino, 2010). Thus, it appears to be a fairly reproducible effect that exposure to disgust results in harsher moral evaluations. Further, these effects appear to be tied to specific categories of moral evaluation in line with broader moral psychology theory.

A caveat to this research is that subsequent experiments using the Wheatley and Haidt (2005) paradigm have suggested that conditioning neutral words with disgust results in the conditioned words being evaluated as more disgusting but not more morally transgressive (David & Olatunji, 2011). The authors of this study concluded with the suggestion that the capacity for disgust to influence morality may be highly dependent on the disgust induction method. It is also important to note that a recent meta-analysis by Landy and Goodwin (2015a) found that although there are many published studies that have found a link between incidental disgust exposure and moral judgement, these effects are small and disappear entirely when accounting for publication bias. Landy and Goodwin (2015a) found that studies inducing disgust through smell or taste appeared to be associated with a much stronger effect on a subsequent moral task; however, Landy and Goodwin (2015b) argued that this could be a result of confounding variables associated with this induction procedure. A response to this meta-analysis by Schnall, Haidt, Clore and Jordan (2015) argued that the amplification of moral condemnation following disgust exposure may be moderated by body consciousness to the extent that the effect only emerges for individuals scoring highly in this personality variable.

In addition to body consciousness being a key variable in this research, an important series of studies by van Dillen, van der Wal, and van den Bos (2012) elucidated the relationship between disgust exposure and moral judgement further by showing the importance of attentional control in moderating the relationship. Disgust was induced in multiple ways (through sentences and videos) and the typical corresponding influence on moral processing was observed; however, measures of attentional control (through both performance in a Stroop task and through self-report) correlated with the effectiveness of the exposure such that attentional control predicted the severity of the moral judgements. Critically, the final study in the series found that either instructing participants to focus on their emotional response to the videos (so as to prevent individuals high in attentional control from emotionally disengaging) or to play a distracting puzzle game (so as to interfere with emotional cognition in individuals low in attentional control) resulted in eliminating the effect of attention as a mediating factor. These results highlight the importance of attentional control (a variable discussed in greater detail in chapter 4.6.2) as an important personality variable in mediating the effectiveness of disgust exposure.

The capacity to feel morally *tainted* (i.e. to experience moral guilt) by close proximity to an immoral person (Eskine, Novreske, & Richards, 2013) or object (Rozin, Markwith, & McCauley, 1994) is a phenomenon interpreted in terms of *contamination*. Research over the last decade does seemingly indicate that feelings of disgust can also contaminate moral assessments so that potential transgressions are judged more disapprovingly and sentenced more punitively. Regardless of whether what is referred to as *moral disgust* is actually disgust or merely an artefact of the language, it does seem as though physical disgust is able to exert a considerable influence over the moral evaluation system, though individuals high in attentional control may have the capacity to override such influences.

3.3.1. The influence of cleanliness manipulations on moral judgement.

One slightly different line of research that has attempted to illuminate the link between disgust exposure and moral judgement involves studies that have induced *cleanliness* rather than disgust. Given that disgust exposure is associated with *increased* moral condemnation it is possible to hypothesise that inducing sensations of cleanliness may have the opposite effect (i.e. reduce moral condemnation). This hypothesis appeared to be confirmed by Schnall, Benton and Harvey (2008), who found that participants who were primed with the concept of cleanliness made less severe moral judgements. This study appeared to provide a parsimonious and intuitive extension of the findings relating to disgust and morality; however, subsequent research has produced results in a very different direction.

In a very influential series of studies, Zhong et al. (2010) provided participants with reminders of cleanliness (through physically washing hands as well as visualising being clean) and found that this resulted in *increased* condemnation of morally contested issues (such as abortion and pornography). This effect was mediated by having an increased moral self-assessment relative to others and was speculated to be a result of "a clean self" feeling more moral thus licensing more severe moral judgements. This interpretation drew on their earlier research that had effectively reversed the induction and outcome measure (in that it had examined whether recalling instances of one's own moral wrongdoing was associated with increased engagement with cleaning related items) – a series of studies that indicated that recollection of immorality was associated with increased use of cleaning words in a word completion task, increased preference for cleaning products and increased likelihood of choosing a cleansing hand wipe as a free gift after the experiment (Zhong & Liljenquist, 2006). These results have been extended by research that has indicated that these environmental cleanliness reminders are associated with taking a more politically conservative stance on moral social issues (Helzer & Pizarro, 2011). This suggests that these environmental manipulations can actually influence political attitude in the short-term (a finding that extends the link between disgust propensity and political affiliation discussed in chapter two as it suggests that these long-term affiliations can also be influenced in the short-term).

Given that inducing the unpleasant sensation of disgust is associated with increased moral condemnation, it is curious that inducing the (presumably) pleasant opposing sensation of cleanliness also seemingly influences morality in the same direction. This is further complicated by the finding of one of the studies in Zhong et al. (2010) that a dirtiness manipulation (through visualisation) did not differ from the control group on influencing moral judgement (a manipulation akin to those that typically influence moral judgement as a result of increased disgust). It is also difficult to reconcile the seemingly contradictory findings of Schnall, Benton, et al. (2008) and Zhong et al. (2010). It is worth noting that a recent replication of Schnall, Benton, et al. (2008) with a much larger sample size failed to reproduce these effects but also failed to produce findings in the direction hypothesised by Zhong et al (Johnson, Cheung, & Donnellan, 2014). A larger sample replication of Zhong and Liljenquist (2006) also failed to find significant effects (Fayard, Bassi, Bernstein, & Roberts, 2009).

The evidence for the capacity of disgust manipulations to result in harsher moral judgements appears to be more consistent than the evidence that cleanliness manipulations can also influence moral assessment (in either direction). Given the repeated findings (in large samples) that disgust propensity is associated with increased conservative values – which typically manifest as increased moral condemnation of acts such as abortion or same sex marriage and increased predilection for harsher punitive sentencing for crimes (see chapter 2.9) – the finding that inducing disgust in individuals can manifest changes to evaluations of these sorts of moral issues in the short-term seems concordant with this and theoretically parsimonious. The mechanisms underpinning such a link between *cleanliness* manipulations and moral judgement are less obvious and more difficult to reconcile with the broader literature on disgust. However, there is some evidence that suggests prejudice can result in an increased need for physical cleansing after exposure to the prejudged group (Golec de Zavala, Waldzus, & Cypryanska, 2014) thus illustrating that there is a link between cleanliness and moral attitude (even if this link may not be related to prior cleanliness exposure).

As it stands, although there are caveats and although the mechanism is not entirely understood, there is good reason to believe that disgust exposure can indeed influence moral decision making. Given that emotional exposure more broadly is capable of biasing emotional perception and assessment as well as more elaborative cognitive assessments, the next section will outline the more limited research that has examined the ways in which exposure to disgust has the capacity to influence visual processing (particularly emotion processing) and emotional assessment.

3.4. The Influence of Disgust Exposure on Perceptual and Evaluative Processes

As disgust is regarded as an emotion that serves the purpose of tuning perceptual and behavioural tendencies to avoid contaminants, it is possible that disgust could influence perceptual and early evaluative processes to the extent that the assessment of incoming emotional or ambiguous information is altered, or short-term behaviour changed. For example, feeling disgusted could result in an increased awareness of any sensory information that could represent an enhanced contaminant risk (including increasing the number of false positive detections), or it could specifically tune the individual to detect disgusting stimuli in the environment that would otherwise be missed or processed more slowly. As disgust is able to alter subsequent emotional decision making (such as moral judgements), it seems plausible that it would also exert an influence on more perceptual processes as well as on other decision making processes.

3.4.1. Physiological and affective properties of disgust induction.

In exploring the consequences of disgust exposure, it is necessary to consider how disgust actually impacts the individual. As has already been discussed (see chapter 1.3), the disgusted expression is associated with reduced capacity for contaminants to enter the organism via the eyes or mouth; more recently, research has also highlighted the other physiological advantages of the disgust response. Rohrmann and Hopp (2008) recorded cardiovascular activity in participants while they watched videos depicting two categories of disgust elicitor (disease and food related) and found increased coactivation of sympathetic and parasympathetic nervous activity (relative to a neutral video). Another key finding was that the disease related films resulted in a decreased heart rate indicative of a *passive-coping-pattern* – a pattern of physiological activity characterised by hypervigilance, metabolic suppression and increased arterial blood pressure provoked by situations where more active avoidance strategies are not available (Schneiderman & McCabe, 1989). Using a similar food related (vomiting) video induction, de Jong, van Overveld, and Peters (2011) found enhanced parasympathetic activity in the cardiac and digestive system, along with sympathetic activation of the cardiac system (thus corroborating and extending the findings of Rohrmann & Hopp, 2008). This study also revealed that these physiological responses were independent of disgust assessment of the videos, or of trait disgust propensity and sensitivity – which is in line with other research that suggests that more external measures of disgust physiology (assessed through facial electromyography and electrodermal activity) appear to be independent of other potentially relevant factors such as having OCD (Whitton, Henry, & Grisham, 2014). Increased cardiac activity appears to be a feature of many negative emotions (Sinha, Lovallo, & Parsons, 1992), so the fact that these studies typically observe *decreased* heart rate in response to physical disgust makes it a physiologically unusual basic emotion and likely reflects disgust's core function as a disease prevention response – where possibly futile (or even risky) active tendencies are suppressed in potentially contaminated environments.

Comparisons of the physiology provoked by physical and moral disgust elicitors through an alternative induction method (a vocal script) revealed opposite patterns of autonomic reactivity for the two disgust types – with enhanced activation of the parasympathetic nervous system for physical disgust and sympathetic nervous system dominance for moral disgust (Ottaviani, Mancini, Petrocchi, Medea, & Couyoumdjian, 2013). The pattern of cardiac activation for physical disgust induced using a vocal script in this study also appears to align with those from studies that have used videos (thus demonstrating that these effects weren't particular to the visual system) and demonstrate that moral disgust appears to be associated with a different physiological pattern to physical disgust (thus contrasting with other studies that have found overlap using other physiological measures such as Chapman et al., 2009). A recent study using a wide range of internal and external physiological measures revealed that physical and sociomoral disgust differ considerably in both the time course and the pattern of activity – with physical disgust provoking a faster and more potent emotional negativity that had an increased capacity to interrupt ongoing processing (Rubenking & Lang, 2014).

Within the categories of physical disgust there also appear to be some dissociations in physiological response. Rohrmann and Hopp (2008) found decreased heart rate for the disease videos (compared to the vomiting ones) and subsequent research has found similar dissociations. Shenhav and Mendes (2014) utilised *core* disgust videos (showing pus and vomit) and blood boundary violation imagery (showing medical injuries) and found that core disgust imagery resulted in reduced gastric activity, whereas medical injuries resulted in lower and more variable heart rate. The authors contended that the affective response to injury may indicate a response that is sufficiently different to not be considered disgust per se, but a response closer to empathy for pain. It is not particularly surprising that exposure to different disgust stimuli results in a different levels of intensity in response (as some elicitors of disgust are clearly stronger than others); however, the pattern of differential physiological activation (with measures even producing opposite autonomic tendencies) between sociomoral and physical disgust, and even within some categories of physical disgust, clearly shows the importance of the precise category of disgust that is used for induction in research – as different elicitors (within the expansive and highly variable range of stimuli referred to in terms of *disgust*) likely produce widely discrepant physiological effects.

3.4.2. Disgust induction through videos.

Most of the major studies examining the physiological response to disgust exposure have used videos as they present a highly intense mood manipulation. Exposure to disgust using this method has been found to have consequences for subsequent perceptual and emotional processes. Conditioning associations between a neutral facial expression and disgusting videos has been found to be associated with attentional avoidance of the face in an eye tracking study – an effect that increased with disgust propensity and that was not reproduced when the face was conditioned with an unpleasant (but not disgusting) video (Armstrong et al., 2014). This study demonstrates the disproportionate aversive reaction (relative to other negative emotions) that disgust can provoke to other stimuli and also highlighted the importance of disgust propensity in mediating the relationship. It is interesting to note that the non-disgusting unpleasant videos depicted vehicle accident injuries, thus further highlighting the dissociation between this category of negative emotion elicitor and elicitors less ambiguously reminiscent of disgust in their capacity to affect subsequent processes (as discussed by Shenhav & Mendes, 2014).

It is clear that disgusting video inductions are able to produce evaluative conditioning effects, and there is also evidence that they have the capacity to influence subsequent emotion processing. Hartigan and Richards (2016) provided evidence that electrophysiological markers associated with post-perceptual emotion processing are increased for disgusted (but not angry) facial expressions following repeated exposure to disgusting videos. This study demonstrated that disgust exposure (through videos) can influence emotion processing but can also do so with specificity – exclusively elevating the subsequent processing of disgust related stimuli.

Within the realm of explicit decision making and actual behaviour, it is established that disgust video manipulations are able to exert an influence on sociomoral assessments such as moral judgements; however, the extent to which this sort of disgust exposure can also influence assessment and engagement with aversive stimuli has also been examined. One study exposed participants (who had blood-injection phobias) to either disgusting or neutral videos before presenting them repeatedly with videos depicting blood draws and found evidence for increased initial fear following disgust activation (Olatunji, Ciesielski, Wolitzky-Taylor, Wentworth, & Viar, 2012). As a caveat, it is worth noting that this study did not find (contrary to predictions) that disgust influenced behavioural avoidance. Another study assessed the influence of context and repetition through comparing repeated presentations of a disgust video elicitor in the same context (the same person vomiting) and the same elicitor in multiple contexts (multiple different people vomiting) on the outcome measures of distress (and physiological arousal measured through skin conductance) towards a novel video, that same novel video a week later, and subsequent behavioural engagement with disgust (Viar-Paxton & Olatunji, 2012). This study found that although participants in the multiple context condition initially experienced more distress to the novel video, their level of distress was substantially reduced to a second (later) presentation unlike the single context condition who experienced a high degree of stress retention between the first and second presentations and increased physiological arousal to the first presentation of the novel video. These results are discussed as being concordant with research that suggests that multiple contexts reduce fear renewal (Bouton, 2002; Vansteenwegen et al., 2007). There was no difference between the groups on a behavioural avoidance (of disgust) task, but they did find that only those in the single context condition showed increased levels of disgust propensity at follow up.

Viar-Paxton and Olatunji's (2012) study is very important to consider when constructing a disgust video manipulation paradigm as it highlights the importance of context. Although the results can be interpreted primarily as evidence for increased distress retention after repeated exposure to the same video, it also demonstrates that initial distress for a novel video is higher amongst people who are exposed to multiple *different* elicitor videos. Thus, for experiments that are concerned with inducing a short-term affective disgust response, it may be more effective to utilise multiple different videos. Overall, it seems clear that exposure to disgust through videos reminiscent of those used in mood manipulation studies (see chapter 3.2.1) can influence automatic attentional capture and heighten affective processing. Evidence that behavioural outcomes can be meaningfully impacted by these disgust manipulations is less clear and it is possible that it is mostly automatic perceptual processes that are impacted.

3.4.3. Disgust induction through images.

Possibly due to the flexibility they provide in ability to manipulate participants' mood on a trial-by-trial basis if necessary, images appear to be the most common disgust exposure stimuli that have been used in the literature. Exposing participants to disgust in this way is typically used to examine the resulting processing biases, rather than the consequences of actually feeling disgusted. Nevertheless, as disgusting stimuli are undoubtedly attention consuming, and a large component of disgust's function appears to come from automatic physiological response, examining the processing biases that are influenced by this type of exposure is extremely instructive in illuminating the temporal dynamics of disgust.

Classical conditioning paradigms that have conditioned responses to neutral words through pairing them with disgusting images have revealed that disgust influences participants' disgust, anxiety, anger, sadness and happiness responses to the conditioned words, but that the biggest effect is to disgust (Olatunji et al., 2013). This study also revealed that disgust propensity predicted the increase (in disgust, anger and anxiety) but was mediated by the intensity of reaction to the disgusting images. There is some evidence that this disgust conditioning effect can be reduced through *counterconditioning* (associating the target with pleasant stimuli; Engelhard, Leer, Lange, & Olatunji, 2014) thus indicating that both individual differences (e.g. in disgust propensity) and ongoing perceptual experience play a role in the extent to which disgust is able to condition these responses. These emotional conditioning experiments may be more instructive to the general examination of evaluative learning mechanisms where the nature of the unconditioned stimulus category (e.g. pictures, words or videos) may be less relevant, but it is interesting to note that conditioning a target with disgust is able to disproportionately provoke a disgusting reaction (relative to other emotions) and does illustrate an emotional concordance effect to some degree. Klucken et al. (2012) also revealed that while the networks underpinning disgust and fear conditioned responses overlap substantially, disgust conditioning is associated with increased insula activation, and high trait disgust is associated with increased coupling between the right and left insula– a finding interpreted as evidence of higher interoceptive sensation (following the model proposed by Paulus & Stein, 2006 highlighting the insula's role in flagging the discrepancy between actual and expected bodily state among individuals with anxiety). Thus, although a central learning mechanism appears to underpin the emotional conditioning response, the conditioning effects of different emotional categories are not equivalent. The subsequent research discussed in this section used paradigms in which the emotional exemplars being images was important to the design and in which specific perceptual mechanisms were explored.

One of the advantages to studying disgust is that the stimuli that provoke the emotion are easily obtainable, recognisable and presentable. Disgust is typically experienced in everyday life in response to objects in the environment (such as dirt or faeces); other negative emotions, such as anger, are harder to embody within a single image without the use of facial expressions. One available paradigm that can be constructed as a result of this is to present disgusted facial expressions (or other emotional stimuli that share this characteristic such as fear) against (or following) a concordant photograph of a disgusting object and examine whether this results in emotionally concordant processing biases (assessed by reaction time or response). Broad emotional concordance effects were previously discussed (see chapter 3.2.2), but many studies that utilise disgust aim not just to examine general emotional congruence, but to explore whether congruence effects are global (i.e. the same regardless of emotional category) or whether there are unique dynamics to the congruence effects of particular emotions and whether these effects are related to individual personality and processing differences.

Some early research that utilised a variant of this paradigm explored contamination fear by presenting a disgust or fear inducing photographic image first alone and then paired with a facial expression (described to participants as an "expression outcome") and found that individuals who were high in contamination fear overestimated the number of times that disgusting images were paired with disgusted or fearful expressions (Connolly, Lohr, Olatunji, Hahn, & Williams, 2009). This study also found that participants high in contamination fear overestimated the number of fear outcomes (relative to disgust) to contamination images thus indicating a negative association not specifically related to emotional congruence. One related approach is to use the dot probe task (Macleod, Mathews, & Tata, 1986) – a spatial cuing paradigm where a threatening facial expression cue is presented on one side of the screen (typically in contrast to a neutral expression on the opposite side) followed by a target probe localised to one side that is identified by participants. Difficulties with responding are typically found in this task when a contralateral probe follows a negative emotional cue – a finding that may be driven in large part by increased difficulty disengaging attention from a negative cue, particularly amongst individuals high in anxiety (Mogg, Holmes, Garner, & Bradley, 2008). Cisler and Olatunji (2010) used this paradigm and found that individuals high in contamination fear experienced difficulty disengaging from both fear and disgust stimuli (particularly when the cue was on screen longer). An eye tracking study using a related cuing paradigm has also found that high contamination fear is associated with increased orientation of attention to fearful (but not disgusted) expressions, but increased maintenance of attention to both fear and disgust (Armstrong, Olatunji, Sarawgi, & Simmons, 2010). These attentional biases are reflected in data using photographic images, where it has been found that high contamination fear is associated with increased gaze orientation to contamination images but shorter fixations (relative to general threat, pleasant or neutral images), and also that these attentional processes mediate behavioural engagement with contamination threats in the real world (Armstrong, Sarawgi, & Olatunji, 2012). This pattern of attentional engagement, followed by avoidance of threat-relevant stimuli, has also been found in individuals with blood injection phobias (Armstrong, Hemminger, & Olatunji, 2013). A variation of the cuing paradigm has also been used to attempt to train participants high in contamination fear to associate disgusting images with positive outcomes (e.g. happy expressions or approach related words) in order to reduce these influences; however, this training does not appear to influence processing biases or behavioural avoidance (Green & Teachman, 2012). These studies demonstrate biases in processing can emerge for particular negative emotional stimuli and that these effects are intertwined with personality variables (e.g. contamination fear) and associated with behavioural outcomes in real world settings. It does appear as though contamination fear results in increased attention to fearful facial expressions and to disgusting (or more specifically, *contaminating*) photographic images thus illustrating that the category of image that represents the emotional stimuli may be as important a factor in influencing processing as the emotional category the stimuli represents.

Outside of the field of contamination fears, differences in processing biases between disgust and other negative emotions have been revealed in other paradigms. Using a letter identification task (where a target letter is presented against a background emotional photographic image after an interval where the image is on screen alone), it has been found that disgust (but not fear) images are associated with increased errors and slowed reaction time (van Hooff, Devue, Vieweg, & Theeuwes, 2013). This effect was only found when the interval between the image prime and the letter was lowest (at 200 ms) and was strongest for the first few blocks. These effects were not influenced by disgust propensity or anxiety. The authors speculate that the results could indicate that, given the rapid attentional orientation typically found to fear stimuli, the smallest interval may have been enough time for fear images to be engaged with and disengaged from such that they did not impede the letter identification, whereas disgust requires a slightly more intricate risk assessment that is more time consuming. These findings appear to corroborate attentional blink emotional paradigms that have found that emotion effects dissipate with increased intervals (Ciesielski, Armstrong, Zald, & Olatunji, 2010). Using a similar letter task, but with reduced intervals and a broader array of emotional exemplars (including disgust, fear, happiness and neutral), it has been found that only disgusting images were able to delay reaction times and only for intervals below 200 ms (van Hooff, van Buuringen, El M'rabet, de Gier, & van Zalingen, 2014). There was a general emotional slowing at the smallest interval (100 ms), but this effect was small and only present in individuals with high anxiety. Pivotally, this study found that these disgust specific interference effects occurred both when the participants were instructed to remember the emotional image and when they were told ignore it, thus indicating that it is difficult to consciously override these disgust effects. Van Hooff et al. (2014) speculate that as well as more detailed assessment of disgusting images (relative to fear) being necessary as a result of the ambiguity, there may be limited costs associated with this detailed processing (unlike fear where failure to stimulate a fast behavioural avoidance may be costly). Although fear stimuli orient attention rapidly, it could be that the enhanced processing that occurs for disgust results in increased interference effects with performance on attentional tasks thus illustrating the range of early processes that exist and that can be selectively interfered with by specific emotions.

Studies that have looked more specifically at the consequences of disgust exposure through images have found that other aspects of perceptual processing and evaluative judgement are influenced. Sherman, Haidt, and Clore (2012) hypothesised that disgust could result in increased ability to detect deviations from a white colour (as it is the colour typically associated with cleanliness to which deviations from may represent dirtiness) and found that greater disgust propensity was associated with increased ability to detect faint grey stimuli against a white background. The final study in this series exposed participants to disgust or fear photographic images and found that exposure to disgust heightened the detection of the non-white stimuli among participants who were high in disgust propensity. These findings are interpreted alongside cross-cultural evidence of lightness being associated with cleanliness (Grieve, 1991) as evidence for disgust biasing perception towards stimuli indicative of impurity. Regardless of whether this interpretation holds, it is evidence that exposure to disgust is able to influence processing and also highlights the importance of disgust propensity in mediating this influence. Presenting participants with disgusting prime images (for 500 ms) has also been found to lower subsequent sexual arousal responses to images of erotica (Andrews, Crone, Cholka, Cooper, & Bridges, 2015). Additionally, participants exposed to slideshows of images representing disease have been found to self-report lower levels of extraversion and openness to new experiences (Mortensen, Becker, Ackerman, Neuberg, & Kenrick, 2010). This study also found that disease primes resulted in increased avoidance tendencies in arm movements and illustrated that disgust exposure can result in behavioural changes as well as changes to self-assessments of supposedly stable personality traits. It is worth noting that these two latter studies only used a disgust manipulation (in conjunction with a neutral control), so it is possible that the results could be related to emotional negativity rather than specifically to disgust.

One study examined the contribution of disgust to implicit biases (assessed through the Implicit Association Test) and found that disgust exposure (through autobiographical memory with disgusting images presented to aid with the recall) increased implicit biases only for groups where disgust was a relevant factor in the out-group stereotype (e.g. homosexuals; Dasgupta, DeSteno, Williams, & Hunsinger, 2009). This study revealed a similar effect for anger induction (in that it increased implicit biases towards Arabs – a group considered to be stereotyped as a result of assessments resulting from anger). However, it is worth noting that the disgust and anger reminder stimuli differed in content beyond just the emotional category (with anger reminders being facial expressions and disgust reminders being photographs of disgusting objects) and this study also contained an unusual emotion induction procedure (combining both images and recall of life events).

The evidence from studies that have exposed participants to disgust (and other emotions) through images appears to indicate that processes can be selectively interfered with both as a result of the type of image (face or photograph) and the emotional category. These studies have also highlighted that a range of individual differences are also relevant in mediating these effects (such as contamination fear and disgust propensity). Regarding disgust specifically, the evidence thus far does appear to indicate that disgusting stimuli produce longer lasting perceptual biases and possibly take longer to fully process than fear – and consequently may potentially produce reduced effects at the very earliest stages of processing. There is evidence that disgust has the capacity to influence ongoing processing to a greater degree than fear does (a finding in line with evidence from the physiology associated with disgust exposure) and exposure to disgusting images does appear to be associated with perceptual influences across quite a diverse range of outcomes (impacting attentional biases, slowing performance in spatial cuing tasks, reducing sexual arousal assessments, increasing detection of shades of grey and potentially increasing implicit biases against specific social groups). Clearly exposure to disgust through still images is a very sound method of bringing out some of the unique properties of disgust and is an important approach to increasing our understanding of the mechanisms and consequences of the emotion.

3.4.4. Disgust induction through physical contact or proximity.

Inducing disgust in participants through videos or images allows for the construction of research paradigms that control presentation timing very specifically and as a result are very well suited to studying the impact of disgust on perceptual processes. Inducing disgust through actual proximity (or contact) possibly limits the range of research goals it can accommodate; however, inducing disgust in this manner is a very direct way of examining disgust where the effectiveness of the stimuli is not curtailed by merely being a symbolic representation of the elicitor. While it may be possible to limit or suppress the response to disgusting visual stimuli when encountered as a photograph or video on a computer screen, inducing disgust through actual proximity is likely the method that best produces the consequences of disgust as they manifest outside a lab environment. It is important to note that a large number of studies use physical proximity with disgusting objects as an outcome measure (such as with the behavioural avoidance tasks) but few use it as an induction measure (or if they do, they do so in the context of examining the consequences on moral judgement), so the literature representing this form of disgust induction appears to be quite small. When inducing disgust through contact or proximity it is important to note that there are factors that influence the perceived disgust of a proximal object. Oum, Lieberman and Aylward (2011) demonstrated that elicitors that were wet and exhibited biological characteristics were rated as more disgusting than dry and inanimate elicitors (regardless of actual contaminant risk), thus providing an indication of which type of disgust elicitors are likely most effective.

Research has demonstrated that prior exposure to a disgusting object (e.g. plastic faeces) is associated with increased attentional orientation towards disgusting pictures in a dot-probe task (Vogt, Lozo, Koster, & De Houwer, 2011). Interestingly, this form of disgust exposure also resulted in increased attention to pictures representing cleanliness – thus further highlighting the link between dirtiness and cleanliness within the disgust schema. Subsequent research has also indicated that emotion suppression (instructing participants to attempt to consciously reduce their disgust response) following this induction procedure resulted in participants attending disgust images (when paired with neutral images) but not attending positive clean images (when paired with disgust) thus indicating that emotion suppression is contingent upon the available distracters (Vogt & De Houwer, 2014). This line of research indicates that physical interaction with disgusting objects is able to bring out the perceptual biases typical of disgust exposure (mainly the attentional orientation towards subsequent disgusting stimuli) through images. However, given that these studies did not present other negative stimuli to participants (such as fear), it is possible that these attentional effects were biasing disgust merely to generally negative stimuli rather than specifically disgusting ones.

The tendency for objects in close proximity to disgusting stimuli to contaminate the non-disgusting objects is of interest to marketers who seek to limit these associations that could result in a reduced propensity in the consumer to buy the contaminated product. Argo, Dahl, and Morales (2006) highlighted the importance of disgust on consumer evaluation by presenting evidence that t shirts were assessed more negatively if they were perceived as being recently worn. Additionally, in an interesting series of studies, Morales and Fitzsimons (2007) demonstrated that disgusting products could "contaminate" evaluations of nearby products through mere proximity. This study found that placing products typically associated with disgust (such as nappies and sanitary towels), even though sterilised and fully sealed, next to non-disgusting products resulted in participants providing lower evaluations of the target product. This association (and the biased assessment of the product it provoked) was found to persist after an hour's delay. Importantly, inducing proximal associations with anger (through proximity between the product and income tax software) did not produce these effects. Morales and Fitzsimons (2007) also illustrated that opaque packaging was able to override this effect (even when the disgusting nature of the contaminating product was still discernible) thus demonstrating that the visibility of the disgust elicitor is extremely important in producing the exposure effects. Cognitive load (manipulated through instructing participants to remember a 10-digit number throughout the procedure) did not influence these contamination effects. This series of studies is important to this research area as it demonstrated clearly the ways in which these disgust exposure effects can manifest in a real world setting and influence people's behaviour while also being quite difficult to override. It also sheds light on the dynamics of this exposure suggesting that direct sensory acquisition of the disgust elicitor is necessary to achieve these effects (simply implying that a perceived disgusting object is proximal is not sufficient), but observing actual contamination (e.g. through a sealed pack breaking) is not necessary. Subsequent marketing research has also revealed that an accidental touch from a stranger reduces product assessments and engagement time in store and this effect is speculated to be driven in part by disgust (particularly sexual disgust in the case of women being accidentally touched by men; Martin, 2012). As a result of this research, disgust has been highlighted as a highly important factor in a review of the most relevant psychological variables influencing product consumption (Ariely & Norton, 2009).

It is important to note that there may be distinct processing systems operating between different paradigms within these lines of research. The marketing research effectively highlights the potential for disgust to create implicit biases (towards proximal products) that result in negative evaluations unrelated to disgust (such as the willingness to purchase the product or to assess the brand as positive); studies that have examined perceptual influences (such as attention to disgust) used conscious engagement with disgusting elicitors as a induction mechanism. Clearly these implicit and explicit induction procedures may result in very different outcomes. Despite these discrepancies in the potential processes that are impacted, the evidence suggests that proximity to, or interaction with, disgust exerts a strong influence on not just our evaluative and behavioural tendencies but also our attentional and perceptual processes. Clearly the nature of the disgust elicitor is extremely important with this form of induction, but it is interesting that stimuli that exhibit some of the qualities of disgusting entities but that do not pose a risk of contaminants (such as the bread dough in Oum et al., 2011) are considered highly disgusting when it comes to interacting with it physically. It does appear that physical proximity is a potent method of inducing disgust as it is able to exert an influence even when there is no visible contamination risk. Disgust induced through this method also appears to have the capacity to influence assessments unrelated to disgust (such as product evaluations) and direct attention towards stimuli that do not represent disgust (such as images of cleaning products). These methods of inducing disgust have revealed the substantial extent to which disgust can influence numerous aspects of perception and cognition beyond mere emotional congruence.

3.4.5. Disgust induction through other means.

There are means of inducing disgust other than through visual exposure. In studies of emotion more broadly individual emotional word presentations are a common way of priming participants and producing perceptual effects similar to those produced by image primes (as demonstrated by Neumann & Lozo, 2012). Despite this being a common method of inducing emotional congruence effects more broadly, research that is concerned specifically with examining the influence of disgust on processing tends to utilise images instead, and thus there are few examples of disgust being explored through this type of elicitor. Another common way of inducing disgust is through instructing participants to read scenarios that present a disgusting situation (as with van Dillen et al., 2012) or instructing participants to remember disgusting experiences (as with Schnall, Haidt, et al., 2008). Interestingly this method has typically been utilised in the study of the consequences of disgust exposure on moral judgement, and induction through visual stimuli is far more common when exploring the influence of disgust exposure on perceptual processes.

However, there are notable exceptions that have made an important contribution to the research on disgust exposure so are discussed in this section. Most notably, an important study on disgust exposure by Cisler et al. (2009) used word primes (representing disgust, fear and neutral categories) and examined their influence on a probe identification task with varied intervals between the prime and the probe. One key manipulation was that half the participants were instructed just to identify the probe (the task irrelevant condition) and the other half had to report the prime word as well (the task relevant condition). In the task irrelevant condition, fear decreased detection more than disgust at small intervals (240 ms or less) but this trend was reversed as the interval increased. In the task relevant condition, disgust resulted in poorer probe detection than neutral at the highest interval (480 ms), but fear was associated with poorer detection at the smallest interval (120 ms). These results suggested an increased difficulty with disengaging from disgust primes (relative to fear) whereas fear primes provoked an increased use of attentional resources in the initial period following the prime that could be disengaged from easier. The fact that the disgust effects only emerged in the task relevant condition implies that conscious engagement with disgust is necessary to produce these interference effects (whereas fear captured attention automatically). An association was found between high disgust propensity and greater attenuation of probe detection following disgust (compared to neutral) primes in the task-irrelevant condition as the interval increased. This study somewhat corroborates other studies that have used a similar paradigm (van Hooff et al., 2013, 2014) in finding that disgust is associated with delayed (or difficult) disengagement whereas fear is associated with greater consumption of immediate attentional resources but faster disengagement. However, it is worth noting that although the overall pattern of these results are similar, the timings are not (with van Hooff et al., 2013, failing to find disgust related effects at intervals above 200 ms); these discrepancies could be a result of the different nature of the primes (with words potentially providing greater interference effects for longer) or simply a result of the task differences on cognitive load (with the constant and repeated processing of words being necessary for the paradigm used by Cisler et al., 2009). Regardless, this study was an important illustration of the differential dynamics of disgust and fear priming and illustrated that conscious engagement with disgusting primes was a factor in increasing its influence on processing.

3.5. Conclusion

Physiologically, exposure to physically disgusting stimuli can be demonstrated to have considerable short-term influences on aspects of both the sympathetic and parasympathetic nervous system. Along with the well documented and publicised influence of disgust on moral judgement, the preponderance of evidence does suggest that exposure to disgust is able to exert a considerable influence over both perceptual and evaluative processes as well. With regard to perceptual processes, disgust appears to be able to provoke aversive responses to otherwise neutral stimuli (such as neutral facial expressions) and increase existing aversive responses in individuals with phobias (such as blood-injection injuries) and anxiety related personality measures (such as contamination aversion). Disgust is an emotion capable of producing the emotional congruence outcomes typical of many priming paradigms (and can do so across multiple categories of elicitor – including words, faces and photographic images). However, what is more interesting is that there appear to be short-term dynamics that are unique to disgust – as it seems to produce a prolonged influence that is more difficult to disengage from than other commonly used negative emotional stimuli (such as fear) and that it is enhanced disproportionately by conscious engagement and emotional rumination.

Regarding more behavioural and evaluative processes, disgust exposure appears to be able to influence short-term decision making outside of the domain of moral judgement, with clear repeatable effects on appraisal of otherwise positive products in a consumer setting. Along with altering short-term implicit biases with a degree of specificity (towards those potentially relevant to prejudice) and reducing sexual arousal, disgust exposure also appears to influence short-term self-reported personality variables (such as extraversion and openness). The potency of these exposure effects is affected by multiple personality variables – most notably disgust propensity (which is repeatedly found to either correlate with the effectiveness of such manipulations or moderate them completely), but also other emotion relevant variables such as contamination fear and anxiety, and by measures of cognitive control.

Disgust can be induced (to such a degree that it produces noticeable short-term consequences) through multiple methods (such as videos, words, sentences, images, physical contact and memory), though the influences on perceptual processes appear to be most commonly induced through videos and images. Other factors that relate to the specific dynamics of the exposure are also relevant, with exposure to multiple exemplars being associated with greater short-term influence (relative to repeated presentations of the same elicitor), but repeated exposure of the same exemplar being associated with greater long-term influences.

This research area is relatively new but has made considerable progress in illuminating the dynamics of disgust exposure and the range of processes it can influence. However, many gaps in the theory remain. This chapter has provided a discussion of the major findings in this area. Chapter four will draw on the conclusions from the first three chapters and lay out the specific areas of investigation and methodological approaches that were explored in the research work (presented in the subsequent chapters) in this thesis with an explanation of how they draw on the literature (particularly the literature that was discussed in this chapter) and further enhance our understanding of the dynamics of disgust exposure.

Chapter 4. Methodological Approaches

4.1. Overview of this Chapter

This chapter will draw on the research that has been presented on disgust theory and the consequences of disgust in the first three chapters, and lay out the range of research paradigms that were selected for the research work presented in the subsequent chapters. Many of the research paradigms utilised (e.g. subliminal priming) have been previously discussed in this thesis, so this chapter will describe the specific research questions that were addressed and the gaps in the literature that the research attempts to fill. Given that a large component of this research was concerned with the ways in which key individual differences have the potential to moderate the influence of disgust, this chapter will outline the selection of individual difference measures that were utilised, including those directly relevant to disgust theory (such as disgust sensitivity and propensity, which have already been discussed in chapter two) and those which are not directly relevant to disgust (and which have not been previously discussed in depth in this thesis) but were nonetheless utilised due to their potential to moderate emotional influences more broadly (e.g. attentional control).

The other major component of this chapter is an outline of the stimuli selected for the experimental work. This section will outline the reasoning for selecting emotional photographs, rather than more commonly used emotional expressions, and will also outline some of the major issues surrounding stimuli selection within the chosen paradigms and the guiding principles that were constructed to inform this selection. The importance of stimuli selection within emotion processing paradigms has been previously discussed in chapter three, but in this chapter some of the issues surrounding stimuli selection are further elucidated.

Most of this chapter draws upon the research findings discussed in the first three chapters; however, the chapter begins with an in-depth discussion of the ERP method and why it was selected as one of the primary approaches to examining the influence of disgust exposure. Although ERP studies are well suited to examining emotion processing and the consequences of prior emotional exposure, most of the relevant existing literature is concerned primarily with broad emotional valence categories (positive and negative) rather than discrete basic emotion categories (such as disgust) and so have not been discussed in detail previously. Given that electroencephalography (EEG) is a measurement tool, not a research paradigm (with EEG studies utilising a wide range of existing experimental psychology paradigms), a discussion of the relevant research motivating the use of EEG was included in this chapter (rather than chapter three where the major relevant research *paradigms* were outlined). The consequences of disgust exposure have predominantly been studied behaviourally, but the first section of this chapter outlines why electrophysiological measures are an appropriate tool for studying this phenomenon and how they can build upon the findings from behavioural methods to illuminate the mechanisms of disgust processing and its perceptual influences.

4.2. An Introduction to Studying Emotion Using ERPs

Event related potentials are electrophysiological responses to specific internal or external events (Luck, 2012) and are typically recorded through an arrangement of electrodes across the scalp that provide an ongoing recording of the changing voltage distribution across the electrode array. Voltage changes across clusters of relevant electrodes (typically averaged across numerous trials and participants) form a waveform, and positive or negative deflections in this waveform over highly specific time periods (following the relevant *event*) form the ERP components which are used as the dependent variables in ERP research. Due to the precise temporal resolution and the potential for examining the earliest aspects of processing prior to conscious engagement (or even prior to behavioural responses of any kind), this approach has been used increasingly over the last decade to study a wide range of psychological (and particularly perceptual) processes. With regard to emotion processing, there are numerous components that are either enhanced or emerge entirely as a result of perceiving emotional stimuli. Variations in the magnitude of these emotional components allow for an examination of the temporal dynamics of emotion processing as well as the factors that can contribute to its enhancement or suppression. Given that many emotion sensitive perceptual ERP components occur before behavioural responses, these provide excellent markers of emotional detection, and examining the ways in which contextual factors (such as prior exposure) influence these components is a valuable method of examining the ways in which such factors influence actual emotion processing. This section will outline the major ERP components that are associated with emotion and provide an overview of what specific processes these components are considered to be markers of. As the research work presented in this thesis is exclusively concerned with responses to visual emotional imagery, only visually evoked components will be discussed.

4.2.1. A note about the N170.

As this research uses exclusively emotional photography (see chapter 4.3.1), the face sensitive N170 component (Bentin, Allison, Puce, Perez, & McCarthy, 1996) is not discussed in detail here. This component appears to reflect the structural encoding of holistic facial stimuli, rather than of specific structural elements (Eimer, 2000, 2011), and there is evidence that it is also further enhanced by faces containing emotional expressions (Batty & Taylor, 2003; Blau, Maurer, Tottenham, & McCandliss, 2007; Smith, 2012; Utama, Takemoto, Koike, & Nakamura, 2009), although many studies fail to find such emotional modulation (Eimer & Holmes, 2002, 2007; Eimer, Holmes, & McGlone, 2003; Schupp, Öhman, et al., 2004). These discrepancies have been speculated to result from differences in reference location – particularly between studies that used a mastoid reference and those that used an average reference (Rellecke, Sommer, & Schacht, 2013) – or from overlap with other emotion sensitive components at this time period (Eimer, 2011).

The emotion sensitivity of the N170 is still a matter of discussion, but it is frequently reported in emotion research regardless. Many studies examine multiple components within an ERP data set and the N170 is often studied in conjunction with other early processing components that are not specific to face processing (particularly the P1); so although there is no section here directly summarising research into the N170, many of the studies that have examined the components outlined in this chapter have also examined the N170 and as a result there are references to the N170 throughout. Even for research concerned with processing of emotional photographs rather than faces, the N170 is still instructive to examine as, if nothing else, it could provide a temporal marker of emotion processing that contributes to our understanding of the point at which emotional discrimination occurs (assuming the N170 is emotion sensitive). Many of the studies referenced in the following sections utilise facial expressions as stimuli, these are discussed as they have implications for emotion processing more broadly (and inform our understanding of the mechanisms the components reflect); however, the primary purpose of these ERP subchapters is to provide justification for the selection of components to analyse – and as the N170 was excluded as a result of stimuli selection, it is not discussed at length.

4.2.2. The P1 component.

The first major EEG component that emerges in response to visual stimuli is the P1 – a positive peak over occipital areas at approximately 100 ms post-stimulus that is likely generated by activity in the extrastriate areas of the visual cortex and likely represents sensory detection and orienting of attention (Hillyard, Vogel, & Luck, 1998; Vogel & Luck, 2000). The P1 is evoked by a wide range of visual stimuli, but there is some evidence that it is enhanced further as a result of processing emotional stimuli. With regard to facial expression stimuli, there is evidence that the P1 is augmented for emotional expressions (Batty & Taylor, 2003; Holmes, Nielsen, & Green, 2008; Pourtois, Dan, Grandjean, Sander, & Vuilleumier, 2005), though some studies have failed to find such emotional modulation (Smith, 2012). Most research exploring the P1 in the context of emotion processing has used facial expressions and there is some evidence that this component is enhanced for emotional faces over emotional photographs (Puce, Allison, & McCarthy, 1999). With regards to the dynamics of emotional expression processing, there is some evidence that the P1 is associated with emotion detection and classification, whereas the N170 is more influenced by intensity assessments (Utama et al., 2009).

The P1 also appears to be susceptible to contextual and priming influences. By using variations of a paradigm whereby emotional facial expressions are presented against a photographic scene that is emotionally concordant or discordant with the face (such as a car crash with a fearful expression), the consequences of these influences on emotional ERPs have been explored. The N170 appears to be sensitive to contextual congruence, whereas the P1 to faces (regardless of expression) seems to be increased (though not substantially) when presented against an emotional (threatening) background – thus suggesting that the P1 is more susceptible to additive and independent emotional factors (Righart & de Gelder, 2006). Variations of this paradigm using scrambled scene backgrounds as a control have revealed similar patterns of ERP results (Righart & de Gelder, 2008) – though it is worth noting that although the broad pattern of results suggest that the scenes did not generate contextual effects after being scrambled, there was still a borderline significant difference between scrambled fearful and scrambled happy scenes that could suggest a small part of the contextual effects were driven by low level features (such as colour).

These contextual effects have also been observed in more typical priming paradigms. Comesaña et al. (2013) demonstrated that priming with pleasant or unpleasant emoticons influenced the ERPs for subsequent positively or negatively valenced words such that the P1 was larger for words that followed a positive prime. Congruence specific effects did emerge in the ERP data of this study, but not until later components (see chapter 4.2.8). Thus, as with the emotional context studies, the P1 effects seem to be driven by additive emotional content rather than emotional congruence. Given that there seems to still be a discrepancy in findings as to whether this emotional augmentation is primarily driven by positive or negative stimuli, it is still not entirely clear what the emotional modulation of this component reflects, however it may be partially driven by task demand and the nature of the paradigm rather than entirely by the stimuli.

The tendency for emotional primes (or emotional context more generally) to influence the P1 has been exploited in studies that have attempted to explore the extent to which different emotional primes influence the P1 in response to other stimuli. Krusemark and Li (2013) presented participants with fear and disgust images before an ambiguous anthropomorphic image; fear was found to increase the P1 to the target (thus corroborating the emotional scene context effects), whereas disgust was found to suppress it (with the emotional effects converging on the subsequent N170 where the effects fuse together to a more broad emotional effect) – a finding that could reflect the discrepant autonomic changes these emotions stimulate (see chapter 3.4.1). Potentially critically to the research presented here, there is also some recent evidence that suggests that although interference effects in a dot probe task are typically found in later components (specifically the P3), interference effects in earlier components can also be observed. Liu, Zhang and Luo (2015) found that anger elicited a larger P1 than disgust to invalidly cued targets. These authors have subsequently found evidence for disgust specific modulation of other early components (notably the N1; see chapter 4.2.3).

There does seem to be evidence that emotional content (whether faces, photographs or words) has the potential to augment the P1. There is also evidence that prior emotional priming or emotional contextual influences can further heighten the P1, but this appears to be a general additive effect rather than one generated by congruence (such that the target may not be relevant for the effect to emerge). Given that there is no specific evidence that disgust has the potential to influence the P1 over other emotions (and even some evidence that it is a suppressive factor), it is not a good candidate component to examine the influence of disgust exposure or disgust processing. ERP research in general does clearly demonstrate that emotional exposure can result in ERP effects, but these are more reliably observed in the later components that are subsequently discussed and the P1 is strongly bound with more low-level perceptual influences so may not be the best component for examining emotional influences.

4.2.3. The N1 component.

Temporally, the next component with potential emotion modulation is the N1 which emerges as a negative deflection after the P1 at centro-parietal regions that peaks at approximately 150 ms after stimulus (Hillyard & Anllo-Vento, 1998) and is typically larger for attended than unattended locations (Mangun, 1995), but may actually represent the process of discrimination between stimuli (Vogel & Luck, 2000). With regard to emotion, the N1 appears to be enhanced for emotionally arousing images (Keil et al., 2001), though it is possible that (within a task free viewing paradigm) it is actually only enhanced for pleasant stimuli (Keil et al., 2002). However, as with many other emotionally sensitive components, whether there is a valence specific effect appears to be in question – with other studies failing to find this relative enhancement for pleasant stimuli (Weinberg & Hajcak, 2010).

The manifestation of the N1 appears to be strongly tied to the nature of the experimental task and the processes required. Using a Stroop task with the instructions to attend either a colour or word placed against aversive or neutral background, it has been found that the N1 is reduced for colour cues (i.e. the more difficult task) but only if the image is aversive (Hart, Lucena, Cleary, Belger, & Donkers, 2012). These results were interpreted as suggesting that emotion could interfere with early anticipatory processes (later ERP markers of anticipatory processes did not produce these effects) but only under conditions where cognitive control mechanisms were more engaged (i.e. when the cue indicated that task was going to be more difficult); the N1 can thus seemingly be suppressed by emotional content when it is a marker of cognitive engagement. The fact that in a more passive viewing task, the N1 is *increased* by emotion (Keil et al., 2001) highlights the fact that the N1 likely (at least to some extent) reflects very different task specific processes. In the context of emotional priming, Comesaña et al. (2013) failed to find emotional priming effects in the N1, finding instead that it was enhanced by emoticon (rather than word) primes (regardless of emotion).

It appears as though in many cognitive psychology paradigms, rather than being a marker of emotion processing, the N1 is a marker of other processes that can be interfered with by the presence of emotion. Nevertheless, there is some evidence that the dynamics of these interference effects can be substantially emotion specific. Gable and Harmon-Jones (2012) manipulated local or global attention by instructing participants to remember either local or global elements of Navon (1977) letters before presenting them with disgusting or neutral pictures. Although the N1 did not differ between disgust and neutral when collapsed across attentional focus groups, disgust images elicited an increased N1 when attention was focussed locally (indeed the pattern was reversed for global attention but not significantly so). This finding was interpreted as suggesting that more resources were dedicated to processing the fine details of the disgusting pictures when attention was manipulated locally, whereas this engagement with fine details (i.e. the elements that would strongly provoke disgust) was suppressed with a global focus. Given that only disgust stimuli were used (for the emotional category), it is difficult to determine to whether this reflects broad emotional or valence modulation more generally. However, a very recent dot-probe study suggests that validly cued disgust *reduced* the N1 (relative to invalid trials), whereas the fear and anger valid cues enhanced the N1 (Zhang, Liu, Wang, Ai, & Luo, 2017). Interestingly, using a marker of attentional bias (by subtracting the N1 for valid cues from invalid ones), this study also revealed that this effect was likely driven by disgust propensity – with correlations indicating that attentional bias for disgust was enhanced amongst participants with increasing disgust (an effect not present for the anger or fear bias scores).

There are undoubtedly interesting effects that emerge in the N1 that are tied to emotion (possibly even tied specifically to disgust), however the task dependent nature of the N1 and the discrepancies between what it likely represents from study to study make it difficult to compare findings. When using particular paradigms (particularly those with a strong influence of attentional discrimination mechanisms), examining the behaviour of the N1 in response to emotion is undoubtedly important, but it does not appear to be the most reliable marker of emotion processing.

4.2.4. The P2 component.

Following the N1 is the P2 component, which manifests as an anterior positivity that peaks approximately 200 ms after stimulus and is thought to reflect attention allocation to stimuli (Luck & Hillyard, 1994; Bigman & Pratt, 2004). With regard to emotion, the P2 tends to be enhanced by emotional (both positive and negative) stimuli relative to neutral (Carretié, Hinojosa, Martín-Loeches, Mercado, & Tapia, 2004; Weinberg, Ferri, & Hajcak, 2013). There is also evidence that the P2 is modulated by facial expression (Ashley, Vuilleumier, & Swick, 2004; Moser, Huppert, Duval, & Simons, 2008) though flanker tasks reveal that this modulation is more pronounced from flanker faces that are negative (Dong, Yang, & Shen, 2009). The P2 is often examined in visual priming tasks, where it is thought to represent repetition suppression (see Freunberger, Klimesch, Doppelmayr, & Höller, 2007), though in oddball tasks it emerges as a target pop-out effect (as with Luck & Hillyard, 1994). Thus, as with the N1, the P2 likely represents broader attentional mechanisms that emotional content has the potential to interfere with.

Studies have also looked at the extent to which context, congruence and mood related effects can impact the P2 and have produced mixed results. Yuan et al. (2011) manipulated mood (through auditory exposure to emotionally evocative sounds) and measured ERPs to a Stroop task; results revealed that the P2 (unlike the later N450 component) was increased for incongruent trials regardless of mood. However, Balconi and Carrera (2011) paired words read in an affective and non-affective tone with facial expressions and found that the P2 was modulated by congruence (thus indicating its role in synthesising multisensory information). This could indicate that that the P2 has a role in decoding sensory information (including emotional information) but is not influenced by the affective state of the individual. There is also some suggestion of a specific modulation of the P2 for disgust (over fear; Carretié, Ruiz-Padial, López-Martín, & Albert, 2011), but the fact that the emotion related activation of the P2 is usually tied to task instruction, and the suggestion that it is not sensitive to mood states or individual differences, makes it a component that is not best suited for the research reported in this thesis.

4.2.5. The N2 component.

The N2 wave is likely generated by numerous functionally distinct components and represents a range of processes, but typically refers to a second negative peak in the waveform that manifests at approximately 250-300 ms after stimulus onset (Folstein & Van Petten, 2008); this peak can manifest at both frontocentral and posterior sites (depending on the process it represents). Folstein and van Petten (2008) describe the three most common components in the N2 complex as representing novelty or mismatch detection, cognitive control and visual attention. Because of the range of independent processes the N2 reflects, emotion studies that reference the N2 are difficult to compare (even more so than other components) as the research paradigms and electrode clusters can differ considerably thus evoking the different components within the N2 complex.

Discrepancies in parts of the N2 complex do appear to be generated by emotion, for example Campanella et al. (2004) found that the N2b oddball component (reflecting attentional orientation) can be delayed for happy (compared to fearful) stimuli, and Kanske and Kotz (2010) found that the N2 was increased by the presence of emotional expressions in a flanker task. However, outside the typical oddball (and other stimuli discrimination) paradigms where N2 variations are typically studied, there does seem to be some evidence that the N2 reflects subliminal emotion detection. Both Kiss and Eimer (2008) and Smith (2012) found evidence that the N2 (or a component broadly similar to the N2 in the case of Smith, 2012) reflected implicit emotion detection – where the component was augmented by the emotionality of the stimuli despite not being overtly detected by the participants. Both of these studies found explicit emotion detection in other components, thus suggesting that the N2 (at least for facial expression stimuli) may reflect an automatic emotional detection mechanism. There is also evidence that the N2 is influenced by the intensity of the emotion; Lu et al. (2016) used an odddball task to elicit a deviant N2 and discovered that extremely fear provoking (but not extremely disgust provoking) stimuli increased the N2. An arousal effect has also been attributed to similar results using facial expressions, as Balconi and Pozzoli (2003) found that the "N230" (speculated to represent semantic information) across frontal electrodes was increased for negative arousing expressions (surprise, fear and anger) over happy or non-arousing negative expressions (e.g. sadness).

With regard to emotion, the N2 is certainly an interesting component, and the evidence that emotion can play a big role in modulating it appears to be substantial. However, the emergence of emotional effects in the N2 is either strongly dependent on the paradigm provoking specific processes (such as those generated in oddball paradigms) or is typically evoked in more passive viewing paradigms only when facial expression stimuli are used. As the EEG research presented in this thesis used photographic images, non-cognitively taxing stimuli presentation tasks, and a mood manipulation, there are better components that overlap temporally with the N2 that provide a more generalisable emotional marker.

4.2.6. The Early Posterior Negativity (EPN).

One of the more common markers of emotion processing (rather than of processes that are influenced by the presence of emotional stimuli) is the Early Posterior Negativity (EPN). This component is a negative going deflection that occurs between 250-300 ms after stimulus over occipital sites that is typically enhanced for visually processed emotional images (Foti, Hajcak, & Dien, 2009; Schupp, Flaisch, Stockburger, & Junghöfer, 2006; Schupp, Markus, Weike, & Hamm, 2003; Schupp, Öhman et al., 2004), but also appears to be further enhanced for highly arousing images (Junghöfer, Bradley, Elbert, & Lang, 2001; Schupp, Junghöfer, Weike, & Hamm, 2004). The typical EPN pattern is to find a general emotional modulation; however, there is some evidence that the EPN is more sensitive to pleasant than unpleasant images (Schupp, Flaisch, et al., 2006; Schupp, Junghöfer, et al., 2004; Weinberg & Hajcak, 2010). It has been suggested that the EPN reflects exclusively conscious emotion processing (Eimer, Kiss, & Holmes, 2008), though research has also found that an EPN for emotional images can be generated even when attention is directed to another task (Schupp et al., 2003; Schupp et al., 2008). Given that these latter studies did not mask the emotional images or present them for time periods short enough to be below conscious awareness (as Eimer et al., 2008 did), this may indicate that the EPN reflects automatic processing of consciously detectable emotional stimuli in the environment. It is also worth noting that although other emotion sensitive components are modulated by aversive conditioning (threat of electric shocks paired with images), the EPN appears to remain only sensitive to the emotional properties of the stimuli (Bublatzky & Schupp, 2012) thus highlighting the component as the marker of emotion processing that is most strongly tied to the properties of the stimuli rather than other factors.

The actual dynamics of the EPN, and the influences it is subject to, appear to be slightly more complex. Enhanced EPN activation for emotional stimuli is observed among individuals with anxiety (Holmes et al., 2008; Mühlberger et al., 2009; Wieser, Pauli, Reicherts, & Mühlberger, 2010) and tasks with high processing demands appear to diminish it (Schupp, Stockburger, Bublatzky, et al., 2007) as does increasing visual noise (Schupp et al., 2008). There is also evidence that, in typical multiple stimuli presentation block design studies, the emotion of the previous image impacts the EPN of the subsequent one such that the target is enhanced by a positive prime (regardless of congruence; Flaisch et al., 2008). Schupp, Stockburger, et al. (2006) also demonstrated that stimulus novelty and repetition did not noticeably influence the EPN. Therefore, the emotional content of a previous image can influence the EPN, but the actual identity of prior images may not – thus highlighting the high degree of emotion sensitivity (over other factors) that the component exhibits. Some non-emotional elements can also exert an influence on the EPN, but these appear to be tied to the properties of the actual image being observed rather than the context of that image against the array of previously observed stimuli. For example, increasing compositional complexity appears to suppress the emotional modulation of the EPN (Wiens, Sand, & Olofsson, 2011), thus showing that even this component, which may be the clearest marker for task-free automatic emotion processing, is also subject to other perceptual influences. It is possible to speculate that the increased difficulty (or delay) in processing more complex images (to the extent that the emotional content can be decoded) could be responsible for this reduced modulation, particularly as the EPN peaks relatively early in processing (this study also found that later emotional components were not subject to these non-emotional influences – see chapter 4.2.8).

As with much research on emotional ERPs, stimuli tend to be grouped in broad emotional valence categories; however, there is some evidence of increased EPN response to disgusting stimuli. Ashley et al., (2004) found that disgusted facial expressions were associated with an occipital negativity in the time period of the EPN (though the EPN is not actually referred to in this study) relative to happy, neutral and fearful expressions. Wheaton et al. (2013) also found that disgusting photographic images revealed this enhanced EPN (relative to fear). However, this latter study appeared to have some other discrepancies between emotional categories (for example, the fear category was the only one to include facial expressions and human figures); although it is difficult to determine the extent to which these factors impact ERPs, it is possible that such discrepancies in stimuli inclusion between studies (and the relative balance of stimuli with other features between categories) is partially responsible for some of the discrepancies in emotional effects that appear in the literature (see chapter 10.4.3 for a more in depth discussion of this issue). One study has explored the difference in EPN in response to different categories of disgust – with data suggesting that words representing core disgust have an increased EPN relative to words suggestive of moral disgust (Luo et al., 2013); however, given that the mechanisms underpinning the processing of words and visual images are likely different, it is difficult to compare this study to studies using visual stimuli. Other studies that have looked for discrepancies between basic emotional categories in the EPN have failed to find increased disgust enhancement relative to other emotions (for example Hartigan & Richards, 2016; Weinberg & Hajcak, 2010). Thus, although there is some preliminary evidence for a disgust specific modulation of the EPN, the evidence is not conclusive and it is possible that these results could be partially attributable to stimuli discrepancies (chapters eight and nine examine this issue in more detail).

4.2.7. A note about the P3.

The P3 (often labelled "P300") is typically divided into several co-occurring components that reflect distinct processes. The typical P3 is a positive deflection in the waveform across midline electrodes at approximately 300 ms after stimulus onset and is generally responsive to stimuli that represent infrequently occurring categories (Polich, 2007). Within oddball tasks, the P3b component refers to deflections resulting from task-defined probability, whereas the P3a tends to be used as a marker of non-task defined improbable stimuli (Luck, 2012). Given that the P3 overlaps both in time and location with the Late Positive Potential (LPP) and the component labels are often used interchangeably (particularly in research conducted in the previous decade) along with the "P300" label, it can be difficult to compare P3 findings across studies (this difficulty is enhanced when other labels such as *Slow Wave* are used for deflections that reflect the *late phase* of the LPP in some studies). Schupp, Stockburger, Codispoti, et al. (2007) identifies a "P3" from 350-650 ms after stimulus and explicitly states that it this component is interchangeable with both the "P3b" and "LPP". However, studies such as Pollatos et al., (2005) distinguish between the "P300" (290-500 ms) and the Slow Wave (550-900 ms) as functionally distinct components. Labels associated with the "P3" are typically used for studies using variants on the oddball paradigm; however, oddball effects are sometimes referred to in an *early LPP* window (i.e. the same window as the P3) in studies where emotion processing is the primary area of investigation. Given that the P3 and early LPP typically refer to the same component (measured from the same electrodes), and the LPP is the label that is the one most associated with emotion processing, studies of relevance to this thesis typically either refer exclusively to the LPP or refer to both the P3 *and* the LPP (for researchers who identify the LPP as a component beginning *after* the P3). As a result of this, although many studies have reported emotional modulation of the P3, this chapter will instead focus on the LPP as the earliest phase of this component refers to the same (or a very similar) process as the P3 and because it is possible to represent the LPP as a component that begins before the P3 (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000) thus making the P3 a slightly redundant component label (both in terms of function and temporal manifestation).

4.2.8. The Late Positive Potential (LPP).

The LPP broadly refers to a positive drift that occurs from as early as 200 ms after stimulus presentation and can last for several seconds (Cuthbert et al., 2000). Given that the main part of the LPP occurs at a point where the peaks typical of earlier components in the ERP waveform are no longer identifiable, it is hard to pick out the various processes that the component indexes, though principal component analysis (PCA) of ERP data reveals that it does appear to represent numerous distinct overlapping components (Foti et al., 2009; MacNamara, Foti, & Hajcak, 2009; Weinberg & Hajcak, 2011). This late positivity has been observed for different regions across studies, but the LPP typically refers to the positive shift measured from centro-parietal electrodes in this time period.

Given the previously described oddball related P3 effects (see chapter 4.2.5), the earliest phase of the LPP appears to be sensitive to task specific oddball targets in a similar way to the P3b. However, due to the potential inherent saliency of emotional targets, it has been speculated that emotional stimuli form "natural targets" even in the absence of task related parameters, thus modulating this "P300-like" positivity (Weinberg et al., 2013). This could explain the repeated and clear finding that the early LPP (or the P300) is enhanced for emotional over neutral (which do not form natural targets) images (Ferrari, Codispoti, Cardinale, & Bradley, 2008; Foti et al., 2009; Weinberg & Hajcak, 2011a). It is difficult to determine whether emotional images are natural targets per se, or whether the early LPP (or P3b) simply indexes emotion processing as well as task related probability. Given that the P3b is a component largely associated with a particular task (or a particular set of tasks), it is difficult to speculate about what the emergence of a P3b (or similar component) outside of such a task represents. As the relationship between emotion and target is additive rather than interactive in the LPP (Ferrari et al., 2008), it is possible that this component can represent distinct processes (though alternatively, it could be that a common attentional neural circuit underlies LPP activity in both oddball and emotional contexts as the authors speculate). Thus, rather than necessitating that the emotional modulation of the early LPP is a signifier of emotional stimuli functioning as "targets" outside of an environment that includes *actual* targets (as they are more typically defined in this line of research), it may simply be that the processes within the LPP contain both an oddball detection system and an emotion processing system. Regardless, the emotional modulation of the LPP by visual images is found to be consistent for time periods extending far beyond the P3 (Cuthbert et al., 2000; Foti et al., 2009; Keil et al., 2001; Schupp et al., 2000) and the fact that this component appears to be modulated by emotional stimuli across tasks (and in passive viewing paradigms) makes it one of the better indexes of actual emotion processing. The specific emotional and attentional process that the LPP reflects is somewhat difficult to determine (given that the LPP is related to many paradigms and subject to many contextual influences); however, there is some evidence that suggests that the LPP may reflect global inhibition of visual cortex activity following emotion processing rather than reflecting enhanced attention to emotion (Brown, van Steenbergen, Band, de Rover, & Nieuwenhuis, 2012). Regardless of specific function, there is little doubt that the LPP is highly sensitive to the emotional properties of stimuli.

There is also evidence that the LPP is sensitive to emotional properties beyond simple binary emotional or non-emotional flagging, and many studies have found that the LPP is also sensitive to valence – with increased amplitude for emotionally negative stimuli (Carretié, Mercado, Tapia, & Hinojosa, 2001; Delplanque, Silvert, Hot, & Sequeira, 2005; Foti et al., 2009; Hajcak & Olvet, 2008; Huang & Luo, 2006; Ito, Larsen, Smith & Cacioppo, 1998). This valence effect may be partially a result of discrepancies in stimuli between studies; Weinberg and Hajcak (2010) found that a certain subset of images sometimes used for the pleasant category (exciting images) and the unpleasant category (disgusting images) had a reduced LPP relative to the other categories in the valence categories. This study also indicated that some subcategories (erotic pleasant images and unpleasant mutilation images) increased the LPP of the valence category relative to the other subcategories. This study highlighted the importance of stimuli selection in emotion ERP studies (and possibly in emotion studies more broadly) and is discussed in more detail in chapter 4.3.1. This "negativity bias" that some studies have reported has also been found to be strongly influenced by the task itself with this bias being more likely in the context of an oddball paradigm rather than blocked or random viewing tasks (Hilgard, Weinberg, Hajcak Proudfit, & Bartholow, 2014). This study also found that a reversed "positivity bias" actually emerged when the images were passively viewed in blocks (with each block corresponding to one valence category) but not in random or oddball paradigms. The authors speculated that subtle latent differences between valence categories could be magnified (to the extent that significant differences were detectable) by paradigms such as the oddball task engaging attentional mechanisms to an increased degree (an interpretation bolstered by the finding that the negativity bias decreased in accordance with overall LPP amplitude across tasks). These studies indicate that more specific emotional differences can influence the LPP (suggesting that the LPP can function on levels beyond broad emotion modulation) but that these influences emerge as a result of the inclusion of specific stimuli and the acquisition of attentional resources within a task.

Evidence that the LPP is sensitive to the *basic* emotional categories (in the absence of other personality or contextual factors) is somewhat lacking, and (relevant to this thesis) there is evidence that threatening and disgusting images result in equivalent LPPs (Wheaton et al., 2013). Though it is worth noting that core disgust words do appear to result in an increased LPP compared to moral disgust words (Luo et al., 2013). If basic emotional categories do diverge in the LPP it seems likely that it will be as a result of generating differential attentional biases or inherently provoking different arousal levels, rather than actually accessing holistic divergent emotional representations. Lu et al. (2016) did however provide evidence that increasing the intensity of emotional representations (using facial expressions) produced different consequences on the LPP, with intensely fearful expressions increasing the LPP relative to intensely disgusting expressions.

Also of importance to this thesis, the LPP is highly sensitive to factors such as mood, context and emotional congruence. Foti and Hajcak (2008) provided evidence that the LPP modulation was subject to contextual framing, as negative descriptions of upcoming images increased the LPP to the image while neutral descriptions suppressed it. Similarly, using PCA, MacNamara et al. (2009) revealed that it was mechanisms embedded in the late part of the LPP that were sensitive to these descriptions, and it has been further demonstrated that these framing effects can persist for as long as 30 minutes after the description (MacNamara, Ochsner, & Hajcak, 2011). It is worth noting that this latter study also revealed that framing influenced the subjective ratings of the unpleasantness and arousal of the images – thus finding a coherence between electrophysiological and behavioural emotional outcomes. Evidence broadly seems to suggest that the early phase of the LPP is influenced primarily by bottom-up stimulus driven qualities that gradually give way to top-down processes as the time from the stimulus presentation increases – a finding also present in oddball studies where the later part of the LPP is exclusively sensitive to top-down influences, but the early part is sensitive to both emotion and target status (Weinberg, Hilgard, Bartholow, & Hajcak, 2012). This finding that the late LPP (after 650 ms) is subject to both emotional and top-down influences has also been corroborated by evidence pointing to an interaction between emotion and stimulus novelty at this point in the waveform – following separate effects of both emotion and novelty (van Peer, Grandjean, & Scherer, 2014). Kisley et al. (2011) and Rehmert and Kisley (2013) also demonstrated that these LPP framing influences could be generated merely by changing the response labels participants used to classify the images – pairing the label "negative" with "less negative", rather than "positive" and "less positive", resulted in a congruence effect (particularly among younger participants).

Studies that have modulated the late phase of the LPP through top-down influences have typically used cognitive manipulations (such as providing a target category for the stimuli or contextually framing the images), however there is also evidence that affective influences can also provide this modulation. Evidence suggests that simply instructing participants to consciously increase or decrease emotional response is associated with an increased or suppressed LPP respectively (Moser, Hajcak, Bukay, & Simons, 2006; Moser, Krompinger, Dietz, & Simons, 2009; Moser, Most & Simons, 2010). Rather than instructing participants to regulate their own emotional response, some studies have also used mood manipulations and found effects broadly similar to the emotional congruence effects. Using facial expressions, recent evidence has demonstrated that exposure to one particular emotion (disgust) can heighten the LPP response to disgusted (but not angry or happy) expressions (Hartigan & Richards, 2016) thus suggesting that these emotional congruence effects may have a greater degree of emotional specificity than previously revealed. Manipulating participants' mood has also been shown to influence the LPP in response to emotional words such that a mood and word incongruence resulted in a suppressed LPP (Yuan et al., 2011). Thus, emotional congruence can emerge from framing as well as mood manipulations and also can seemingly influence an array of emotional exemplars (photographic images, facial expressions and words).

However, there is some evidence against the notion that contextual influences always affect the LPP in an emotionally congruent direction. Rapid presentation paradigms have revealed that a target image can be suppressed simply by the previous image being emotional rather than neutral (Flaisch et al., 2008). Similarly, Comesaña et al. (2013) showed that the LPP in response to emotional target words was enhanced when the preceding prime word was positive. These studies did not find clear congruence effects, thus potentially suggesting that that it is not simply emotional congruence that modulates the LPP. As with other components, the wide range of discrepancies between task, stimuli and emotional manipulation across studies makes it difficult to compare results. Given that the later phase of the LPP is subject to top-down influences, it is possible to speculate that the mood or expectancy framing manipulations (such as those used in studies that have found congruence effects) are more likely to provoke such top-down modulation, whereas trial-to-trial priming may be too much of a stimulus driven influence to create the lingering affective or cognitive changes necessary to modulate the LPP in an emotionally congruent direction. It is also worth noting that both Flaisch et al. (2008) and Comesaña et al. (2013) examined only an early phase of the LPP (neither study analysed effects beyond 660 ms after stimulus), which is before the time period typical for congruence effects to emerge.

There is also evidence that the LPP can be influenced by individual differences. As with the EPN, evidence suggests that anxiety increases the LPP (MacNamara, Ferri, & Hajcak, 2011; MacNamara & Hajcak, 2009, 2010; Mocaiber et al., 2009; Moser et al., 2008; Weinberg & Hajcak, 2011b). Other psychological factors such as interoceptive sensitivity also appear to increase the LPP in response to emotional stimuli and do so similarly to how they influence emotional assessment (Herbert et al., 2007; Pollatos et al., 2005). These two factors (anxiety and interoceptive sensitivity) are associated with enhanced physiological response to emotional content, so if the LPP reflects increasing allocation of attentional resources to emotional stimuli these personality variables would be expected to modulate it. However, there are other candidate individual difference variables that are also worth examining given what is known about the LPP (see chapter 4.6).

In conclusion, although the LPP is a component that likely reflects multiple processes, emotional modulation is a central component. Given that the research work presented in this thesis is concerned with examining the extent to which prior emotional exposure can influence subsequent emotional perception, the wide range of contextual, cognitive, affective and priming influences that the LPP is subject to make it an invaluable marker for the processes this thesis is concerned with. The early and middle sections of the LPP in particular marks the point at which the properties of the stimuli interact with top-down processes and represents a process that is likely to be most impacted by the individual differences also explored in this thesis.

4.3. Stimuli Selection

4.3.1. Emotional photographs and emotional expressions.

The most common types of stimuli for evoking emotional responses are facial expressions and photographs aimed at eliciting particular emotions (commonly referred to as "emotional scenes" in the literature). As discussed by Sabatinelli et al. (2011), face stimuli provide the advantage of being more easily controllable (with matched facial models ensuring that the only differences in the stimuli directly reflect the muscular changes necessary for a different expression to manifest), but scene images are more heterogeneous (with each scene being distinct enough to contain considerable structural variability within a given emotional category), and also more environmentally realistic. With regard to the neural regions responsible for their processing, Sabatinelli et al. (2011) found substantial differences between faces and scenes (in their activation over a neutral contrast), but also found a strong area of overlap (mostly in the bilateral amygdala). Given the differences between processing emotional faces and scenes (and the discrepancies between the non-emotion related structural processing regions their processing recruits), it may not be possible to clearly generalise results from studies that have used these discrepant stimuli (nor to combine these categories into one set within a single experiment).

The selection of stimuli category is likely to vary in accordance with the specific area of investigation. An advantage of using facial expressions is that they enable the targeting of specific basic emotional categories more easily, whereas emotion scene images are more typically used to reference broad valence categories. There are also some common basic emotional expression categories that are very hard to represent with emotional scenes (such as anger and surprise). Thus, experiments that compare the processing of numerous emotional representations are generally best suited to using expressions. However, as evidenced by their use in mood manipulation studies (see chapter 3.2.1), emotional scene images appear to evoke a more intense affective state and are likely better for studies examining actual affective emotional states rather than emotional identification. For studies of subliminal (and supraliminal) visual priming (see chapter 3.2.2), Neumann and Lozo (2012) have demonstrated that such effects can manifest at the level of the semantic emotional category, thus implying that the stimuli type in such paradigms may not be as relevant. Although the research work in this thesis is partly concerned with biases in the detection of information related to disgust in the environment (and how they are influenced by prior disgust exposure), the extent to which such exposure can influence the unpleasant visceral experience of aversive stimuli is also central to the thesis. The central question of the thesis is whether the disgust exposure effects that result in enhanced *moral disgust* also result in an enhanced processing of emotional stimuli. Given the strong physical disgust response to numerous elicitors that are easily depicted in photographs, this makes emotional scenes a better category of stimuli for the work in this thesis – and thus, scene images were used across all studies.

4.3.2. Structural properties of emotional scenes.

Many ERP studies that have utilised emotional scene images use both photographs that centre on the facial expression of a central figure as well as more general emotional scenes within the same set (a subject discussed in chapter 10.4.3). Rather than the more rigorously controlled facial stimuli sets used in facial expression studies (such as the NimStim database; Tottenham et al., 2009), the expressions contained in these photographs depict different individuals against discrepant background scenes that also vary in the extent to which the rest of the body is visible. Aside from discrepancies in functional activation between facial expression and emotional scene processing, studies have also demonstrated that broader body language influences early ERPs evoked by facial expressions (Meeren, van Heijnsbergen, & de Gelder, 2005) and ERPs in response to faces are enhanced additively with the emotional content of the background scene (Righart & de Gelder, 2006). Thus, there is reason to believe that these expression photographs are subject to a number of known perceptual influences that the other scene images are not. There may still be reason to use such a wide range of emotional exemplars (e.g. to attempt to represent the very broad basic emotional category), but it seems likely that the inclusion of such facial expression photographs in certain emotional categories but not others within a single study may create a confounding variable. As the disgusting images were chosen to evoke a strong visceral response in participants, this precluded the inclusion of facial expressions for this emotional category. In order to create balance between this and the other stimuli categories, photographs containing emotional expressions were excluded from all other emotional categories in the research presented in this thesis.

Studies have demonstrated that picture complexity (represented by whether the scene had a simple figure-ground organisation or a more complex composition) can influence early emotional ERPs (Bradley, Hamby, Löw, & Lang, 2007; Wiens, Sand, & Olofsson, 2011) thus suggesting that preserving the level of complexity across stimuli categories is imperative. Given that images that provoke a disgust response can be depicted simply as a single central elicitor against a background, for the ERP studies, a simple figure-ground composition was used for all stimuli. In general, across all experiments, only images judged to have low levels of complexity were included. Many of the images commonly used in prior studies also appear to include discrepant levels of windowboxing (i.e. they include horizontal or vertical black borders) such that the aspect ratio of the various images can diverge substantially between many of the most commonly used scenes. In order to prevent any confounding variables relating to the framing of the images on screen, only images without windowboxing were included in the research in this thesis. The included images also used a consistent resolution of 1024 x 768 and larger images were cropped where necessary to accommodate this. The only exception to this was for the first experiment, where images were instead cropped to a portrait resolution of 512 x 768 in order to be consistent with the dimensions of smallest sized image selected from the International Affective Picture (IAPS; Lang, Bradley, & Cuthbert, 2008) database – as IAPS images were used exclusively for this experiment.

Stimuli were selected to represent the emotional (or neutral) categories exclusively with low levels of ambiguity. After each experiment, ratings were taken from each participant to ensure that they represented the relevant emotional category (more details for this rating task are provided in chapter five). Along with disgusting stimuli, pleasant (including pleasant food images), threatening and neutral images were selected for inclusion (across the various studies). Details for each of these categories are provided below and see Appendix A for a full list of all the IAPS images used in all the experiments in this thesis.

4.3.3. Disgusting stimuli.

Images were initially selected for inclusion exclusively from IAPS. This initial selection was informed by previous studies that have referred to a *disgusting* category, but were only included if they had the structural elements described above. The initial selection included images of wounds, entrails, mud, faeces, vomit, rubbish and animal corpses (however a preliminary rating task, reported in chapter five, was conducted with a wider range of categories). Partially due to the rating task following the first experiment (see chapter five), corpses and rubbish were removed from subsequent sets and the subsequent experiments had a more consistent selection of disgust images (though there was some variation).

With regard to images of corpses, the lack of visual focus on many of the IAPS images representative of this subcategory, combined with the absence of many of the properties traditionally considered physically disgusting (such as the wet and *seeping* qualities as discussed by Miller, 1997, and demonstrated experimentally by Oum et al., 2010), made them a subcategory that was not included in the subsequent experiments. These corpse images are certainly judged *disgusting* by participants, but it is possible that they could be used to form a category of emotional stimuli that also evokes *sadness*. Some images that included corpses were included in a set for a subsequent experiment (see chapter six), but these images were not drawn from IAPS and were included because the images included exposed entrails or infestations (qualities typically regarded as disgusting), rather than the corpses themselves being the elicitor. With regard to the images of strewn rubbish contained in the IAPS database, these are also certainly regarded as disgusting, but the rating task of the first experiment (see chapter five) revealed that these images evoked lower levels of disgust than the other subcategories and thus were not retained for future experiments. IAPS images depicting mutilation are often utilised as *disgust* exemplars; however, following the first experiment these were not included again as the strong visceral unpleasantness experienced in response to viewing images of close-up human injuries is arguably not best conceptualised as *disgust* per se. There is evidence that these types of mutilation images evoke a much stronger emotional response electrophysiologically than more typical core disgust images (Weinberg & Hajcak, 2010) and also provoke a different pattern of metabolic response (Shenhav & Mendes, 2014). The authors in the latter study argued that this type of disgust response (to violent injuries) may be better conceptualised an empathy for pain. Even if these images do evoke disgust, there is reason to believe that they are substantially more unpleasant than the response to the disgust images that represent the type of disgust that is actually of relevance to this thesis.

With the exception of the initial study, the IAPS images in the disgust category were supplemented with images from elsewhere. This ensured that images could be found that more easily met the required structural characteristics and also enabled the creation of sets with an increased number of high quality exemplars within each disgust subcategory (as the number of images for many of the identified subcategories in the IAPS database are limited). To find the additional images, public online image depositories were used (such as Flickr, Shutterstock and Wikimedia Commons). Additional images were included only if they were judged to contain a single identifiable disgust elicitor which was concordant with the initial subcategories of disgust identified in the IAPS database. Thus, although many additional images were included in the experiments, no additional type of disgust elicitor was used that was not present in the IAPS images. Ratings of disgust, threat and pleasantness were taken after each experiment, and for the disgust images these ratings were used to construct stimuli sets that were rated high in disgust but low in threat. The rating task results are reported for each experiment in the results sections.

4.3.4. Threatening stimuli.

The purpose of including *threatening* as a stimuli category was to have a set that was also negatively valenced in order to examine whether effects related to disgust were specific to the emotion or reflected effects related to negative emotions more generally. As scene images were utilised, *fear* remains the only basic emotion category that is easily embodied by such stimuli. As with the disgusting images, it was important to find images that elicited fear in participants but that did not also induce disgust (or did so minimally). As such, many of the subcategories used to evoke fear in other studies (such as spiders) were not included (following the results of the preliminary ratings study reported in chapter five and the ratings task of each experiment). There is also prior evidence that the aversive reaction to spiders is driven in large part by disgust (de Jong & Muris, 2002). Despite fear being potentially the only negative basic emotional category available to studies utilising scene images, there are other advantages to using fear as a contrast for disgust. Unlike anger – which has considerable overlaps with disgust in both facial expression identification (Pell & Richards, 2011, 2013; Skinner & Benton, 2010) and lexicon (Shaver et al., 1987) – fear has been conceptualised as an emotion that contains many of the opposite physiological tendencies to that of disgust (Susskind et al., 2008). Behavioural tasks have revealed that there do appear to be differences in the extent to which processing can be disrupted by disgust and fear (van Hooff et al., 2013, 2014). However, both disgust and fear (unlike anger) are emotions associated with behavioural avoidance (Frijda et al., 1989; Hertenstein, Keltner, App, Bulleit, & Jaskolka, 2006) and scene images representing the two emotions appear to stimulate a similar affective network (Stark et al., 2003, 2004). It is also worth noting that the explicit assignment of self-reported anger or disgust in response to some specific appraisals (namely moral phenomena) does seem to vary considerably and rely heavily on the range of terms available within the experiment (see chapter 1.3.3) thus demonstrating a substantial degree of overlap (at least at the conceptual level). Thus, disgust and fear provoke similar end behaviours, but these behaviours emerge from a substantially different set of processes and provoke very different psychological experiences. Therefore, there is good reason to believe that fear is a more appropriate unpleasant emotional category than anger to use as a contrast with disgust as it is similarly unpleasant, but processed very differently. In terms of the actual structure of fear-inducing scene images, the emotion can be provoked by images of a similar composition to that of disgust (i.e. a simple composition with a single central elicitor).

The subcategories that formed the overall threatening image group were images of snakes, threatening dogs, alligators, sharks and weapons. Sharks, dogs and alligators were included as it has been argued that these large threatening animals (unlike some smaller animals and insects) do not also evoke disgust (Matchett & Davey, 1991). Images in the weapon category depicted guns (and one image in the research in chapter five depicted a knife) aimed towards the camera; some of these images contained visible human hands, but images with visible faces were not selected. For all the other subcategories, the image depicted a single threatening animal. As with the disgust stimuli, images were selected that resulted in rating task scores with high levels of threat but comparatively low levels of disgust.

4.3.5. Pleasant stimuli.

Along with disgusting and threatening images, some of the experiments also utilised a pleasant category. In studies utilising IAPS images, this category often contains images of happy people and appealing food images. For the experiments presented in this thesis, images with faces were excluded. Additionally, some of the experiments conducted examined responses to food stimuli specifically (see chapters five and seven); as such, this subcategory (food) was not used to represent the broad pleasant stimuli (as it has in other studies). The remaining IAPS images that are typically used to represent the pleasant valence category tend to include flowers, plants and attractive natural scenery, and as such these were the stimuli used for the pleasant category in the work presented here. Unlike disgusting and threatening images, there were sufficient images within the IAPS database to form the category without additions from other sources. These images either depicted a single central pleasant entity (e.g. a flower or a plant) or they presented a pleasant landscape scene. For the latter subcategory, only scenes that did not include multiple focal points and were not visually noisy were selected.

The selected food images were of a simple composition, depicting a single pleasant edible item (or a single plate of food). To minimise potential visual overlap with the entrails subcategory of the disgust stimuli, no images containing meat or fish were selected for inclusion. The selected food images were of high valence (according to the IAPS normative ratings and additionally informed by the ratings task after each experiment) and predominantly included images of fruit and vegetables, along with images of sweet desserts and confectionary (such as cake and chocolate bars). More details on the food images are provided in the relevant chapters (see chapters five and seven), but the broad reason for their inclusion was to explore the long discussed link between disgust and digestion.

4.3.6. Neutral stimuli.

The final category of stimuli was a non-emotional neutral category. This category was composed entirely of simple household items (such as clocks and cups) with the specific exemplar inclusion informed (again) by the normative IAPS ratings and the rating tasks of each experiment (where low levels of pleasant, disgust and threat were the criteria for inclusion). With the exception of chapters eight and nine (which included five new stimuli), all neutral images were selected from the IAPS database. All were of a similar composition depicting an item against a neutral natural background.

4.4. Research Paradigms

There are several possible approaches to examining the contribution of disgust exposure to the visual processing of emotional scenes. ERP methods are very suitable for examining the short-term neurophysiological changes present in the perceptual biases brought about through disgust exposure. However, behavioural methods with a focus on emotion classification can provide evidence for biases at the evaluative level. Behavioural reaction time paradigms (particularly in the form of visual priming studies) also have a long history of clarifying the influence of perceptual biases. The work in this thesis uses ERPs, reaction time and emotional classifications as the dependent variables to various studies. However, these paradigms, when used as measures to examine the influence of disgust exposure, provide markers for very different processes (all of which were of interest to the central question of the thesis). This combination of paradigms and outcome measures tapped a range of early perceptual processes and thus allowed for a more comprehensive examination of the role of disgust exposure in modulating such early emotion processing.

There is already a considerable body of work highlighting the subliminal and supraliminal biases of prior emotional primes on the speed of processing a subsequent target image (see chapter 3.2.2). As has previously been discussed, the effects that typically emerge are representative of emotional congruence. If the prevailing theories about emotional priming are accurate, priming disgust in these paradigms should simply result in perceptual biases towards disgust targets as a result of activation of the semantic emotional information. With this mechanism, exposure to disgust through visual priming should be no different from exposure to fear; prior research supports this with the finding that emotional scene images produce the same congruence effects for both disgust and fear (Neumann & Lozo, 2012). However, it is worth investigating whether disgust and fear congruence effects are equivalent even for individuals at different levels of trait disgust. If an individual is more prone to experiencing disgust, or does so with an increased aversive response, then it is possible that they may also have an increased level of vigilance for disgusting information to the extent that it can modulate disgust (but not fear) visual priming congruence effects (see chapter 4.6.1 for more information on the disgust trait measures selected). If such a bias exists, it is worth examining whether it exists on a temporal level (manifesting with discrepant reaction times to disgust congruent pairings) or whether it increases the number of disgust target classifications the individual gives. The research presented will also examine whether explicit emotional assessment is necessary to bring about any congruence effects, or whether they also emerge when a target image is being evaluated on non-emotional criteria.

Visual priming studies allow for the examination of visual biases, but they are not appropriate for examining the contribution of disgust exposure manipulations that are more consciously or affectively processed (such as mood manipulations). Reaction time and explicit classification of emotional images may still be influenced by such a manipulation however. This type of paradigm is useful for examining whether disgust exposure can alter emotional assessment of an otherwise pleasant or neutral image. IAPS images depicting food are typically rated as pleasant, but given the role of disgust as an oral rejection response (Darwin, 1872/1998; Rozin et al., 1995), it is possible that disgust exposure could impact the affective response to these images. As such, a rapid emotional assessment paradigm was utilised to explore this issue – this paradigm was set up as visual priming paradigms are, but without the prime images (see chapter seven for more details).

Regarding EEG methodology, the paradigm of most interest to examining the consequences of disgust exposure on emotion processing is the serial visualisation task. This is a simple task where ERPs of several categories of emotional elicitor are summated and examined. Given that emotion related ERPs manifest even in the absence of a task, this type of paradigm is appropriate for examining automatic perceptual influences that occur prior to a behavioural response. If ERP components related to emotion diverge following disgust exposure (compared to a neutral control) then it is clear evidence that disgust has the capacity to influence emotion processing even at the perceptual level. One alteration made from the classic serial visualisation task was the inclusion of a required response from participants on a small percentage of trials (see chapters eight and nine for more details); this was included to ensure that participants remained focussed on processing the images and also because previous work has shown that this conscious emotional engagement may be necessary for such exposure effects to manifest electrophysiologically (Hartigan & Richards, 2016).

4.5. Disgust Manipulations

This thesis was concerned with the affective and perceptual influences of a range of types of disgust exposure. The choice of disgust induction method is an important one, as prior research has argued that the capacity for disgust to influence behaviour may be highly contingent on the specific stimuli used for exposure (see David & Olatunji, 2011). As one of the core issues explored in this thesis was the extent to which specific visual priming effects can emerge for disgust (that are not also present for fear stimuli), prime images were selected from the IAPS database, with the same criteria used for both primes and targets (see chapter five and six for more details). For this paradigm, only disgust information that is quickly presented and rapidly processed is appropriate, and thus images are the only reliable method of visually priming disgust.

Disgust was also induced through written scenarios. This method has been used in previous studies (van Dillen et al., 2012) and allows for the construction of very customisable disgust exposure stimuli that are easily matched with a control (neutral) exposure category. By encouraging participants to remember such written scenarios while engaged in a subsequent emotion perception task (behavioural or electrophysiological), the contribution of conscious engagement with (and rumination on) disgusting events on such processing can be examined. This type of manipulation is appropriate for perceptual discrimination tasks (see chapter seven) or serial visualisation EEG paradigms (see chapter eight), and by examining the consequences of disgust exposure on both behavioural processing and automatic electrophysiological response, both attention-directed and automatic emotional exposure effects can be examined.

A final method of disgust induction was through videos (see chapter nine). This has proven to be a very potent method of disgust induction that has resulted in strong behavioural and physiological outcomes (see chapter 3.4.2). This method of induction differs from the presentation of sentences to remember as it requires less cognitive engagement and resembles more the classic mood manipulation used in the literature (see chapter 3.2.1). This sustained visual induction method exposes participants to physical disgust in a way that is closer to how it is encountered in everyday perceptual experience. The resulting affective response to emotional images and perceptual biases that emerge thus can be considered to result from a lingering affective state (or a priming of the visual system to be more receptive to certain categories of emotional stimuli).

4.6. Individual Difference Measures

One of the core questions this thesis aimed to answer was whether the influence of disgust exposure on early emotion processing was moderated by trait differences. The role of individual differences in disgust has previously been discussed at length (see chapter two) and its relevance to the work in this thesis is self-evident, but the nature of the paradigms selected (and what processes they are known to recruit) also made attentional control a subject of interest. This section provides an overview of the reasons for including the relevant self-report measures as well as the details of the specific measures used.

4.6.1. Trait disgust.

A central question to this thesis was whether trait disgust modulated the impact of disgust exposure on emotion processing. It is possible that high levels of disgust are necessary to facilitate the investigated effects, or otherwise it is possible that trait disgust controls the potency of such effects. Given the numerous self-reported measures of disgust that are commonly utilised in psychology (see chapter two), there are several potential measures that could be used. The primary measure selected was the DPSS-R as it included both measures of disgust propensity and sensitivity. Disgust propensity widens the range of stimuli to which an individual ascribes a disgusted response (van Overveld et al., 2006) and this is relevant to the work here as the experiments conducted examine the response to a range of aversive stimuli (both disgusting and threatening). Disgust sensitivity describes the subjective unpleasantness the individual feels when encountering disgusting stimuli, and this affective response may increase the unpleasantness of disgust manipulations and thus result in an increased perceptual bias. There has been some criticism of the potential circularity in the wording of the items in the DPSS-R (see Berle et al., 2012), but nevertheless it does seem to be a good approximation of both the trait disgust variables it aims to represent.

Given the generalised disgust factor that many disgust measures are speculated to represent (see chapters 2.7 and 2.8), a single marker of general disgust may be most appropriate for the work in this thesis (rather than the subdomains referenced in many other commonly used questionnaires). However, the research presented in chapter six utilised both the DPSS-R and the DS-R. The DS-R was included predominantly to examine whether disgust propensity effects were driven by a particular disgust sub-scale – with that particular questionnaire selected as many of the disgust stimuli represented entitities that were animal reminders, and those that could be associated with contamination fears. However, for subsequent experiments a single marker of disgust propensity was considered most appropriate as there were no hypotheses relating to specific subtypes of disgust propensity.

4.6.2. Attentional control.

Attentional control is a variable that is purported to moderate the relationship between disgust exposure and assessments of morality (Armstrong et al., 2013; Sherman et al., 2012; van Dillen et al., 2012); it is therefore instructive to examine whether it also moderates the influence of disgust exposure on more perceptual outcomes. In addition, the nature of the tasks utilised in the research in this thesis are likely to require a certain degree of attentional control. Although masked priming studies effects are considered to be *automatic* (i.e. independent of cognitive influences), there is evidence that top-down attention can modulate even subliminal priming influences (see Kiefer, Adams, & Zovko, 2012) so it is possible that even paradigms that do not utilise more explicit disgust exposure are susceptible to attentional influences. Kiefer et al. (2012) argue that attentional control increases the detection of task-relevant information and the attenuation of irrelevant information; thus, it is possible to infer that attentional control should enhance the rapid classification of images according to their emotional content, and possibly reduce priming influences (as they do not aid classification). With regard to the EEG research, the LPP is commonly regarded as a marker of attentional allocation, with the emotional deflection resulting from the inherent salience of emotional stimuli (Ferrari et al., 2008; Weinberg et al., 2012). As a result, the ability to control attention may reduce the emotional deflection of the LPP, or otherwise moderate an LPP deflection that emerges following disgust exposure. With regard to disgust specifically, it has been speculated that disgust propensity, for some elicitors, is associated with reduced grey matter volume in prefrontal regions and may indicate that it is associated with a lack of cognitive control (Scharmüller & Schienle, 2012). Thus, for the methods of disgust exposure, the specific paradigms, and the specific emotion under investigation, attentional control may be an important factor in moderating the results.

It is possible to provide a marker of attentional control both through experimental tasks and self-report. Both these methods were used in the present research, with a negative priming Stroop task (Tipper, Bourque, Anderson, & Brehaut, 1989) used in the first experiment and the Attentional Control Scale questionnaire (ACS; Derryberry & Reed, 2002) used for the other experiments. The ACS was used as it provides both a marker of attentional focus (the ability to concentrate and consciously recruit attentional resources) and shifting (the ability to direct attention to a new task) which are both variables that could modulate the link between disgust exposure and engagement with another task. For the experiments that required participants to read and remember disgusting scenarios as a method of inducing disgust, attentional shifting may facilitate the engagement with the main task (while the sentences are held in working memory). Attentional focus, on the other hand, may more directly allow participants to disengage from disgust exposure that did not require memorising such that another task could be engaged with. Another reason that the ACS was also used in subsequent experiments (over a cognitive task) was that it reduced the overall experiment time for participants, thus ensuring they remained engaged with the main task (which could take a considerable amount of time to complete).

4.7. Analysis Strategy

As this thesis had a focus on the extent to which individual differences influenced disgust exposure, an analysis plan utilising linear mixed model Analysis of Variance (ANOVA) was selected. Unlike with standard ANOVAs, this approach allowed the relevant individual difference measure to be entered into the primary analysis as a continuous variable. The primary analysis for each experiment was an emotion x exposure group x individual difference measure (with the specific emotions and exposure groups differing depending on the nature of each experiment). After an initial emotion x exposure linear mixed ANOVA was performed (examining main experimental effects), each of the four identified individual difference measures (disgust propensity, disgust sensitivity, attentional control and attentional shifting) were entered into a separate analysis as a continuous variable. These mixed ANOVAs used *orthogonal contrasts* (as described by Singmann & Kellen, *in press*) with type III sum of squares that were only interpreted at the level of the highest order interaction (and only for results where an interaction with the continuous variable was significant). For all analyses, the participant was entered as a random effect. Following significant effects in this main mixed

ANOVA, post hoc analyses were conducted to elucidate these main effects. As a result of difficulties with obtaining reliable standardised effect size calculations for mixed models (see Singmann & Kellen, *in press*), follow-up analysis was conducted primarily using bivariate correlations in order to provide an indication of the magnitude of the continuous variables' effects. More information specific to each experiment is provided in the method and results sections of each subsequent chapter, but this broad analytic approach was used throughout.

4.8. Overview of Subsequent Chapters

The remainder of this thesis reports the results of the experimental work and their implications for the broader literature. The order of these chapters reflects the order in which the experiments were conducted. Chapter five presents the results of a subliminal visual priming study that tested whether the processing of images of food was influenced (over other positive stimuli) by a prior disgust image (over a prior threatening image). Chapter six presents a visual priming study (using both short and long prime durations) where broad prime-target emotional congruence effects were examined, with the primary hypothesis that disgust sensitivity (or propensity) could facilitate emotional congruence for disgust but not threatening stimuli. This chapter also presents the results of a second task (on the same set of participants) where emotional congruence effects were examined when a non-emotional assessment of the stimuli was made. Chapter seven presents a rapid emotional assessment study, where the influence of prior disgust exposure (through written scenarios) on the processing of food (over other pleasant stimuli) is examined. Chapter eight reports a serial visualisation EEG task, where emotional ERPs are examined following exposure to disgusting or neutral written scenarios. Chapter nine reports an EEG task with an identical paradigm to that of chapter eight, but manipulated disgust through more sensory visual exposure (videos). Chapter ten provides a discussion of these findings and how they contribute to our overall understanding of disgust exposure.

Chapter 5. Does Visual Priming with Disgust Influence Responses to Food Images?

5.1. Introduction

There is a long established link between disgust and food that goes as far back as Darwin's representation of disgust as "something offensive to the taste" (Darwin, 1872/1998, p. 255). This association between food and disgust is one that appears to be established in children from as young as five years old, who have been found to rate the taste of food believed to be contaminated as more unpleasant – even when no contamination has actually occurred (DeJesus, Shutts, & Kinzler, 2015). This conception of taste is central to many accounts of disgust (see chapters 1.3.1 and 1.3.2) and it has been speculated that disgust (as it exists today) is an emotion that is descended from distaste evolutionarily (Chapman et al., 2009; Chapman & Anderson, 2012). While other accounts of disgust emphasise the broader role in protecting the individual from contaminants (Curtis et al., 2004; Curtis, de Barra, & Aunger, 2011; Herz, 2014a), rejection of food is still a component of this broader function and it is clear that disgust and the digestive process are strongly linked. Disgust and taste are both associated with activation in the anterior insula (see chapter 1.4), and the link between these has been highlighted behaviourally in research that has demonstrated that taste sensitivity itself is a correlate with sensitivity towards moral violations containing visceral disgust elicitors (Herz, 2011, 2014b). Importantly, Herz (2014b) demonstrated that priming individuals to disgust (through the use of a questionnaire that used the disgust rather than the anger lexicon to assess moral scenarios) resulted in taste sensitivity increasing the severity of response (even when the scenarios did not contain disgust elicitors). This study indicated that it was merely utilising the language of disgust to assess a moral scenario that brought out the effects of taste sensitivity (regardless of the actual scenario) and highlights the strong link that exists between taste and disgust.

Eating behaviours in general have been found to be linked to disgust. Houben and Havermans (2012) found that individuals with a propensity towards more restrained eating habits also had higher levels of core and contamination related disgust propensity. Indeed, disgust propensity does appear to be strongly associated with eating disorders (see chapter two) and phobia of vomiting is also associated with abnormal eating habits and reduced body mass index (Veale, Costa, Murphy, & Ellison, 2012). Disgust is linked to many psychopathological conditions, but it does appear as though conditions associated with abnormal eating patterns are heavily contingent on disgust (although the direction of causality in this relationship is difficult to infer). On an interpersonal level, there is evidence that the disgust experienced in response to the food preferences of others can result in interpersonal negative assessments that extend far beyond the actual food consumed (Rozin, Markwith, & Stoess, 1997; Steim & Nemeroff, 1995). Thus, disgust and food consumption are strongly linked and can result in consequential psychopathological and social outcomes.

With regard to the visual processing of food stimuli, there is evidence that food images appear to increase activation in limbic and paralimbic structures associated with reward processing, and prefrontal structures associated with cognitive control (García-García et al., 2013). This review of the literature also concluded that disorders associated with overeating (e.g. obesity) were associated with an over active reward processing circuit when viewing food images, whereas disorders associated with rigid controls over food intake (such as anorexia and bulimia) were associated with increased activation in the medial prefrontal cortex (interpreted as being indicative of consciously directed efforts to restrain eating). There is also recent evidence that unpleasant images of food suppress activity in the motor cortex associated with the tongue in the same way that images of disgusted facial expressions do (Vicario et al., 2016); moreover, the magnitude of this tongue motor activation suppression was dependent on levels of disgust propensity. Calder at al. (2007) also demonstrated that higher disgust propensity resulted in increased activity in the insula in response to disgusting, but not appetising or bland, food images. Thus, although the neural activation associated with perceiving food images is complex (seemingly involving prefrontal areas associated with cognitive control and limbic areas associated with reward in addition to the anterior insula activity), there does appear to be some degree of overlap with stimuli that are overtly representative of disgust and disgust propensity does appear to modulate this activation.

Vicario et al. (2016) and Calder et al. (2007) highlighted the link between disgust and perception of unpleasant food stimuli, but it may also be instructive to examine whether the perception of pleasant food can also be influenced by disgust. Although Calder et al. found no modulation of appetising or bland foods as a result of disgust, there is a commonly referred to notion that disgust can put us off food, even when the food is otherwise pleasant – even Darwin notes that "a smear of soup on a man's beard looks disgusting, though there is of course nothing disgusting about the soup itself" (Darwin, 1872/1998, p. 255). It may be the case that pleasant food images are not related to disgust propensity when viewed without prior emotional exposure, but that exposure to disgust results in more unpleasant responses to otherwise positive food images. It is possible to speculate that if disgust can *contaminate* images of food in this way, it may do so only after persistent conscious engagement with disgust, or simply exposing individuals to prime images of disgust may be sufficient to alter perception of food stimuli. The former of these hypotheses is explored in chapter seven, but the research presented here examines whether visual priming of disgust images can influence responses to pleasant images of food (over other pleasant images).

Thus, the experiment presented in this chapter utilises visual priming. Both disgusting and threatening images were used as primes in order to explore whether any potential effects were specific to disgust, or whether broad emotional negativity was sufficient to achieve effects. Disgust propensity and sensitivity measures were taken from participants as trait disgust has been strongly implicated in the processing of food images. Likewise, due to the recruitment of attentional control in the processing of food images (and also due to the potential capacity for attentional focus to override priming), measures of both attentional control and shifting were taken from participants. Prior to this experiment, a short rating task was also conducted using a wide range of IAPS images to produce a refined stimuli selection; the main purpose of this task was to gather preliminary assessments of both threat and disgust (variables not examined in the IAPS normative ratings), though the images were also rated for other emotions. The results of the rating task are presented in brief before the priming experiment.

5.2. Ratings Task

A total of 166 images were selected from IAPS to show to participants. These included 36 disgust, 31 fear, 44 food, 16 pleasant and 39 neutral images. The disgust images included insects, mutilation, mud, faeces, dirt, rubbish, animal corpses and animals with disfigurements. The fear images included snakes, spiders, aggressive dogs, sharks, alligators, weapons and an image of an aggressive tiger. The food images included meat, fish, fruit, desserts and confectionary. The pleasant category included images of cute animals and butterflies. The neutral category contained images of household items. The main purpose of the task was to select disgust and fear images for the experiment, but selection of food images was also informed by the results. Other categories of image (pleasant and neutral) were simply shown to participants to lower the overall proportion of unpleasant images within the set.

The participants (n = 6; 3 female) had an average age of 39.5 (SD = 17.4) and rated each image individually (with a randomised order) on a 7-point scale for how disgusting, threatening, anger-inducing or pleasant they found each image. The overall results (for the broad emotional categories) are presented in Table 1, though the purpose of the ratings task was to examine the responses to the individual images for selection in the experiment. From these results a selection of disgust, fear and food images were chosen for the experiment.

Table 1. Mean (*SD*) ratings for each emotional category (row titles) for each response scale (column titles).

	Anger-inducing	Disgusting	Pleasant	Threatening
Disgust	1.72 (0.78)	4.10 (1.35)	1.74 (0.31)	1.69 (0.52)
Fear	1.20 (0.45)	2.00 (0.61)	2.17 (0.57)	3.85 (0.91)
Food	1.03 (0.09)	1.47 (0.29)	4.36 (0.89)	1.18 (0.25)
Neutral	1.12 (0.20)	1.17 (0.19)	2.89 (0.71)	1.33 (0.30)
Pleasant	1.06 (0.15)	1.16 (0.18)	5.19 (0.83)	1.30 (0.38)

5.3. Main Experiment Method

The order of the task was as follows: participants first completed the Stroop task, then the subliminal priming task, then the ratings task, and finally the questionnaire. Across all studies in this thesis, questionnaires were completed after the experimental task so that participants were not ruminating on the disgust scenarios in the questionnaires while completing these tasks. This was in order to ensure that participants' responses were not biased towards disgust stimuli due to a factor that was not the experimental exposure manipulation.

5.3.1. Participants.

A total of 32 participants (between the ages of 18 and 55) took part in the experiment. One participant was excluded from the analysis due to excessively slow response time – with an overall RT (collapsed across prime and target type) above 1100 ms (and over 1.5 multiples of the interquartile range above the upper quartile value). Thus, 31 participants were retained for analysis. All of the retained participants were right handed, and 19 were female. The mean age for the sample was 28.68 (*SD* = 7.32).

5.3.2. Stimuli.

A total of 48 images were included in the experiment. These included 16 each of disgust and pleasant, along with 8 each of fear and food stimuli. The disgust stimuli included images that depicted mutilation, exposed entrails, vomit, faeces, mud and rubbish. The pleasant stimuli depicted images of plants, flowers and landscapes. The fear stimuli depicted images of snakes, sharks and guns. The food images depicted desserts, confectionary and fruit. The discrepancies in number of exemplars between the stimuli categories reflected the status of the category as either prime or target only (in the case of fear and food) or as both prime and target (in the case of disgust and pleasant).

In order to visually mask the stimuli in the priming trials, a set of 24 pattern masks consisting of black and white visual noise were created. These masks approximated those used in Neumann and Lozo (2012) and were created in MATLAB by randomising a 192 x 128 array of pixels as either black or white. The resulting image was then upscaled to four times the size so that it matched the 768 x 512 dimensions of the images.

5.3.3. Stroop task procedure.

This negative priming Stroop task was based on the design used by Tipper et al. (1989). Rather than simply examining response delays for trials where the colour and word conflicted (as with the standard Stroop task; Stroop, 1935), this version also includes a block of trials where the distractor (the word) from the previous trial is the target (the colour) in the subsequent trial. These *ignored repetition* trials prime participants away from a correct response (as correctly identifying the subsequent target requires them to inhibit their suppression of the previous distractor), thus specifically requiring inhibitory control to override the priming and to make a rapid correct response. Consequently, this may provide a marker of participants' ability to suppress priming influences from previously processed stimuli.

The Stroop task contained four blocks of 30 trials each. One block represented a control block where the word was merely a string of Xs, thus not generating interference effects. Another block represented the congruent condition (where the colours and words matched). One block represented the incongruent condition (where the colours and words conflicted). Finally, there was a repetition block (where the previous distractor formed the target as described above). The order in which participants encountered each block was randomised. Participants were instructed to identify the target colour as quickly as possible using one of six response keys (representing red, purple, black, yellow, blue and green). Before each trial, participants saw a fixation cross (on screen for 500 ms) to orient their gaze. There was also a 500 ms blank screen before each trial. In between each block, participants took a short break.

The variable derived from this task that was used in the analysis was the marker of inhibitory control. This marker was calculated by subtracting the mean RT for the ignored repeated trials from the mean RT of the incongruent trials (a procedure used by Vitkovitch, Bishop, Dancey, & Richards, 2002). This results in a value that factors out the standard response inhibition of a classic Stroop task – resulting in a score that specifically reflects participants' ability to override the negative priming influence thus indicating good attentional control. Given this aptitude is likely to also facilitate an individual's ability to override the effect of an emotional prime (such that the emotional classification of a subsequent image is not impacted), this was considered the most relevant attentional control variable to derive from the Stroop task and thus was the only attentional control variable used in the analysis.

5.3.4. Priming task procedure.

This task consisted of four blocks of 144 trials, with a five minute break in between each one. For each trial, participants were instructed to decide whether each target image was *pleasant* or *unpleasant* using a left or right response key (which was counterbalanced across participants). Each trial began with a fixation cross for 1000 ms, followed by a brief 40 ms prime image (the same duration used in experiment 1 of Neumann & Lozo, 2012) and then a target image that remained on screen until a response was made. Following each trial, there was a 500 ms interval (see Figure 1). Before each prime there was a visual mask for 300 ms, and a different 50 ms mask followed the prime (so that the primes were both forwards and backwards masked). The prime in each trial varied between disgust, pleasant or fear (with pleasant primes only included to vary the valence of the primes that participants were exposed to over the experiment), and the targets varied between food, pleasant and disgust. Within each block there were two unique primes for each stimuli category (six unique primes in total for the block), and eight targets (24 targets in total). The trials within a block consisted of one instance of every unique prime and target combination. Across blocks, the targets remained the same, but the primes were novel (with two new primes for each stimuli category in each block). This meant that over the experiment, each of the 24 prime images were combined with each of the 24 target images once. As the stimuli used for the primes and targets were distinct (i.e. no image was both a prime and a target), each stimulus' status as either prime or target was counterbalanced across participants (with the set representing primes and targets reversed). This was in order to help ensure that results were driven by the stimuli category, rather than by potential biases in the structural elements specific to the primes or targets. The order of blocks was also counterbalanced across participants so that the order in which participants encountered the primes was reversed for half the participants.

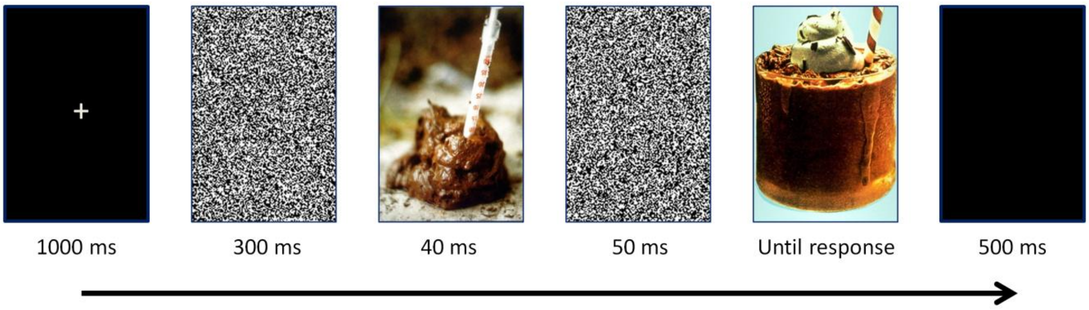

Figure 1. Experimental paradigm. A brief prime that varied between disgust, pleasant and fear was followed by a target stimuli (varying between food, pleasant and disgust) that remained on screen until participants indicated whether it was pleasant or unpleasant.

5.3.5. Rating task procedure.

Participants were shown all the images used in the experiment on screen and instructed to rate each one on a 7-point scale for how disgusting, threatening and pleasant they found each image. Images were presented in a random order. Following the rating task, participants completed the DPSS-R, with measures of both propensity and sensitivity calculated.

5.4. Results

5.4.1. Pre-processing and results strategy.

Prior to analysis, all responses under 200 ms were excluded. An overall mean RT was computed for each participant (collapsed across prime and target categories) and all trials with responses falling 2.5 standard deviations above or below this value were excluded (as was done in the first experiment of Neumann & Lozo, 2012). This pruning procedure was used consistently for participants in all RT experiments across this thesis as it is in line with the procedures used in the literature most relevant to this aspect of the thesis (e.g. Neumann & Lozo, 2012). In addition, the first five trials of each block were excluded. As well as measuring RT, the proportion of unpleasant responses given in response to targets was also calculated with this value arcsine square root transformed for analysis in order to curtail the effects of the anticipated skewed distribution of unpleasant responses within the food and pleasant categories in the analysis. The primary analysis of both RT and response data was performed using a linear mixed model ANOVA (as described in chapter 4.7) with prime (disgust vs. fear) and target (food vs. pleasant) entered as within subject fixed effects and the negative priming Stroop score, along with disgust propensity and sensitivity entered separately as continuous variables. As pleasant primes were only included to vary the valence of the primes, the results of these trials were not analysed. Disgusting targets were also included to ensure that a subset of the images participants responded to included stimuli that are typically regarded as unpleasant in order to ensure that the targets did not provoke an exclusively *pleasant* response throughout the experiment. Neither the pleasant primes, nor the disgust targets were used in the analysis. The rating task scores were used to provide overall scores for each stimuli category, and specific subcategories of stimuli were also examined and used to inform selection in subsequent experiments.

5.4.2. Stroop task results.

The scores for each block in the Stroop task are reported in Table 2. There was a significant slowing of RT in the repetition condition compared to the incongruent condition according to a within-subject *t* test ($t(28) = 2.11$, $p = .043$) suggesting that the repetition trials were indeed more difficult than the incongruent trials.

Table 2. Stroop test results for each condition.

	Control	Congruent	Incongruent	Repetition
Mean (*SD*)	743.92 (168.64)	825.73 (284.47)	891.79 (266.94)	943.17 (260.99)

5.4.3. Priming RT results.

Means for both RT and transformed response proportions can found in Table 3. The main prime x target analysis revealed a significant main effect of target, with food targets being significantly slower ($F(1, 30) = 22.97$, $p < .001$); however, critically, there was no prime effect or interaction (*F*s < .39, all *p*s > .53). There were no effects related to individual differences in response inhibition (all *F*s < 1.75, all *p*s > .20). There was a significant interaction between target and disgust propensity ($F(1, 30) = 4.92$, $p = .029$) with slower responses to food targets as propensity increased. This was examined in more detail by creating an average response time to food targets variable (collapsed across all three primes) and correlating it with disgust propensity, however the resulting correlation was not significant (p = .38). There were no significant effects associated with disgust sensitivity (all Fs < .2.17, all ps > .14).

Table 3. RT and arcsine sqrt transformed proportion of unpleasant responses means (*SD*) for each prime/target combination.

	Disgust prime		Fear prime	
	Food target	Pleasant target	Food target	Pleasant target
RT	655.11 (121.61)	629.05 (135.39)	656.98 (131.51)	623.05 (120.54)
Responses	.40 (.31)	.22 (.27)	.37 (.31)	.19 (.25)

5.4.4. Priming response results

The main prime x target analysis revealed a highly significant main effect of target (F(1, 30) = 50.9, p < .001) with increased unpleasant responses to the food targets, but no prime effect or interaction (all Fs < .1.80, all ps > .18). There were no effects related to response inhibition (all Fs < .2.52, all ps > .12). However, there was a target x disgust propensity interaction (F(1, 30) = 6.90, p = .010) with increasing unpleasant responses to food stimuli with increasing levels of disgust propensity. There was a similar (but stronger) target x disgust sensitivity interaction (F(1, 30) = 7.54, p = .007) in the same direction. To examine these trait disgust effects, a difference score indicating the increasing unpleasant responses for food (over pleasant) stimuli was created (collapsed across primes) and then correlated with both disgust variables; however, correlations with this measure were not significant for either disgust propensity (p = .11) or sensitivity (p = .09).

5.4.5. Rating task results.

The overall rating results for the three stimuli categories for levels of disgust, threat and pleasantness reported by participants is presented in Table 4. Of particular interest were the subcategories of disgust, in which images of dirty toilets were rated the most disgusting at 6.48

(*SD* = .97), followed by the mutilation images at 5.80 (*SD* = 1.27) and mud/faeces images at 5.58 (*SD* = 1.19). Images of strewn rubbish evoked comparatively lower levels of disgust at 4.86 (*SD* = 1.57) and were not used in subsequent image sets for the experiments reported in this thesis. All three subcategories of the fear stimuli evoked high levels of threat, with shark images averaging at 6.18 (*SD* = 1.11), gun images at 6.09 (*SD* = 1.16) and snake images at 5.74 (*SD* = 1.34). The food and general pleasant images resulted in comparable pleasant assessments (thus reflecting the normative IAPS ratings).

Table 4. Mean (*SD*) ratings for the levels of disgust, threat and pleasantness for each stimuli category.

Ratings	Disgust	Fear	Food	General pleasant
Disgusting	5.80 (.94)	3.18 (1.60)	1.62 (.76)	1.27 (.47)
Threatening	3.67 (1.57)	6.01 (1.05)	1.17 (.44)	1.41 (.41)
Pleasant	1.34 (.36)	1.80 (.69)	5.22 (1.17)	5.90 (1.01)

5.5. Discussion

This experiment investigated a very specific hypothesis – that the processing of food images could be impacted by disgust (relative to fear) primes in a way that other stimuli of positive valence could not. This hypothesis was not supported by the results. The food targets were both slower for participants to respond to, and classified as unpleasant more often, but the prime category did not influence this. However, the finding that higher disgust propensity and sensitivity resulted in slower responses and an increased number of unpleasant responses to food images (relative to generally pleasant images) does highlight the importance of disgust in such evaluations. There were no statistically significant findings related to inhibitory control.

The most commonly obtained emotional priming effect is a processing benefit for a target that is preceded by a congruent emotional prime (see chapter 3.2.2). The experiment reported here examined whether the processing of pleasant food images could be influenced by disgusting primes (representing different emotional and valence categories to the target). The fact that no such priming effects were established may be an indicator that the mechanisms that emerge as a result of priming do not facilitate disgust's tendency to impact subsequent processing and assessment. It may be that actual affective, phenomenological experience of disgust is necessary to bring out the processing and behavioural effects that are typical of other research on disgust exposure (such as the mood manipulations reported in chapter three). When a disgusting stimulus is presented as a subliminal prime, it may only be able to bias information processing rather than affective systems. If this is the case, it may still be possible for longer presented supraliminal primes (on screen for long enough for participants to fully and consciously process them) to exert an influence on the assessment of food images.

In order to examine these issues in more detail, it is important to determine whether more potent, lingering disgust mood manipulations are able to influence the processing and assessment of food images. A better way to facilitate this investigation would be to construct a between-subject experiment – testing the effects of a disgust mood manipulation (compared with a neutral equivalent) on the processing of food images; this was the procedure used for the experiment reported in chapter seven. It is also worth noting that it may be more instructive to examine disgust and fear priming effects in contrast with pleasant (or neutral) primes (i.e. primes that differ in emotionality or valence). This experiment included pleasant primes, but as it was necessary to also include pleasant targets (as a contrast with food targets), the effects of pleasant primes could not be examined (as pleasant targets preceded by pleasant primes would result in a congruence confound independent of emotional effects). Similarly, it may have been useful in this experiment to examine whether increased disgust sensitivity or propensity was associated with a greater priming effect for disgust targets preceded by disgust primes (that is, whether trait disgust increased the congruent processing benefit exclusively for stimuli associated with disgust or whether it also affected other aversive stimuli). Chapter six reports an experiment that was designed to examine this issue (as well as other more general priming effects) and test whether prime and target congruent processing could emerge specifically for disgust when participants were instructed to identify disgusting stimuli. In order to examine the specific food related priming effects of interest here, the potential scope of this experiment was necessarily reduced. However, the experiment indicated that if exposure to disgust is associated with changes to the processing of food images, brief disgust primes that are on screen for time periods considered to be subliminal are not sufficient to produce these effects.

One finding of interest was that both disgust sensitivity and propensity were associated with different responses to the food targets (regardless of primes). The slower assessments for food images as a result of trait disgust could suggest that these images are associated with an increased ambiguity; the finding that they also resulted in a higher number of unpleasant responses (despite the high pleasant assessment in the rating task) suggests that there may be an increased difficulty with accurately assessing food images on emotional criteria when a fast response is required. The relationship between trait disgust and the processing of food images is explored in more detail in chapter seven.

Chapter 6. Trait Differences that Influence Emotional Congruence in Visual Priming

6.1. Introduction

Processing emotional information appears to be associated with a subsequent influence on perceptual and evaluative processes (see chapter three). The capacity to detect emotional information quickly may carry an adaptive advantage – enabling individuals to detect threats in the environment and select an appropriate behavioural response more readily. Biasing perceptual systems towards identifying stimuli of the same emotional content to that which has been recently perceived could facilitate this process. This would make sense (adaptively) in particular when it comes to the negative emotions. Threatening or disgusting entities in the environment may not be encountered in isolation, and the ability to identify an environment with such risks and become hyper aware of subsequent similar risks could be an important one for helping individual navigate such environments.

The results from chapter five suggested that processing food images could not be influenced by disgust primes that were of a duration considered (based on previous research) to be subliminal; however, this chapter examines the more general case of emotional congruence in priming – specifically examining the extent to which it facilitates disgust processing. Previous research suggests that emotional priming emerges from prior activation of semantic categories (Neumann & Lozo, 2012), but Rohr et al. (2012) discovered that this priming does not always occur at the level of the emotional category. The evidence that broad valence effects can emerge has been long established, but Rohr et al. found that subliminal priming influences could emerge at the level of the behavioural tendencies associated with the emotion (e.g. approach or avoidance). Subsequently, Rohr and Wentura (2014) established that priming at the level of the emotional category could occur under supraliminal conditions. It is interesting, given the discrepant influences on processing disgusting and fear related visual stimuli appear to have (see chapter 3.4.3), that priming results appear to be driven predominantly by congruence – a factor that is not affected by the different influences disgust and fear have on processing –, even when the primes are supraliminal. If (as non-priming paradigms have indicated) the processing of fear images is associated with rapid identification and a short disruption to processing, whereas disgust is associated with a slower but longer influence that is more difficult to disengage from (van Hooff et al., 2013, 2014), then it is interesting that these discrepant processing influences do not manifest in priming studies.

One way to explore the dynamics of visual priming is by examining whether individual differences in susceptibility to one particular emotion heighten priming influences for that emotion specifically. If priming effects emerge predominantly as a result of congruence, it is possible to speculate that such susceptibility may increase the congruence benefit obtained for that particular emotion. Thus, this chapter explores whether disgust propensity or sensitivity is associated with increased priming effects when specifically evaluating stimuli for whether or not they are disgusting. The primary hypothesis examined in this chapter is that trait disgust increases the priming congruence benefit for disgust. As individual differences in disgust are central to the issue examined in this chapter – as it is the only experiment presented where the main experimental effects (without individual difference measures) would add little to the existing literature (significant priming effects would merely duplicate existing results and serve to corroborate existing emotional priming theory) –, this experiment used the DS-R along with DPSS-R. If effects related to disgust propensity were found, the DPSS-R enables an examination of the extent to which these were determined by generalised disgust or sensitivity towards specific subdomains of disgust stimuli.

Thus, disgust and neutral prime and target combinations are examined. In order to examine whether any potential trait disgust influences are specific to disgust (or reflect a broad valence modulation), threatening and neutral target combinations are also examined. By assessing whether stimuli are disgusting, congruence effects should only manifest for disgusting stimuli. If they also emerge for fear related stimuli, then this may have implications for the extent to which priming can facilitate the identification of specific emotion categories.

There are several variations in priming experiments that appear to influence results. The most obvious of these is the length of the prime – effectively determining whether the trials tap subliminal or supraliminal processes. Rohr and Wentura (2014) demonstrated that priming effects manifested at the level of the individual emotional category only when supraliminal primes were used (along with a wide range of emotional categories), whereas Neumann and Lozo (2012) used only a binary response option (two emotional categories) but found subliminal congruence effects. Thus, it remains unclear whether subliminal or supraliminal primes are necessary to bring out these emotional congruence effects. Rather than using a wide range of prime durations, the experiment in this chapter used only two (40 and 250 ms) in order to produce trials that drew on both subliminal and supraliminal mechanisms (with 40 ms being used as it was the prime duration used in experiment 1 of Neumann & Lozo, 2012). Although these prime durations are regarded as representative of subliminal and supraliminal trials (in both Neumann & Lozo, 2012 and Rohr & Wentura, 2014), there is still great difficulty with verifying that the emotional content of trials with even very brief durations (as low as 33 ms in Rohr et al., 2012) cannot be detected (see for example the awareness check results in Rohr et al., 2012 and Rohr & Wentura, 2014). Thus, there is difficulty with establishing whether or not the different pattern of results associated with short prime durations are actually a result of primes being truly non-consciously processed or simply result from them being on screen for a reduced period. The intention in this experiment was to explore both subliminal and supraliminal prime durations; however, the different processing patterns associated with disgust and fear (see see chapter 3.4.3) mean that even if the short primes did not tap subliminal processing, it would still be worth investigating whether congruence benefits for specific emotions are contingent on extended durations, and whether such a benefit is specific to either disgust or fear.

Another factor that may be of interest is the nature of the decision. Typical priming effects emerge from tasks where the response option requires identification of the specific emotional label. This type of response option should draw on processes related to task-relevance, and by instructing participants to respond using these labels, participants should already be consciously reflecting on emotion. However, if emotional information is processed implicitly (without consciously directed attention), it is possible that participants who appraise a target image on non-emotional criteria may experience interference when a prime and a target are of the same emotion. Prior research has suggested this is an important factor in mood related disgust exposure effects (Hartigan & Richards, 2016), but it is instructive to examine whether it is also required for visual priming effects to emerge. To this end, the experiment in this chapter included a second task constructed identically to the emotional priming study, with the exception that an assessment of a non-emotional criteria was included (the number of colours). This decision ensured that participants were still engaging with and assessing the stimuli, but on non-emotional criteria.

For the emotional decision task, rather than using response labels associated with the specific emotion, this experiment used a binary "yes" or "no" response option. This allowed for a task lower in difficulty (due to the reduced number of response options) that enabled the specific targeting of one emotion (disgust). Thus, participants were asked to indicate whether they found each target image disgusting or not. This type of assessment also potentially enables the manifestation of other processing effects. If there is a tendency for disgust stimuli to *contaminate* the appraisals of other stimuli, then it is possible that neutral stimuli will be appraised as more disgusting following a disgust prime. This would not be evidence related to congruence, but it would have implications for the ways in which disgust can influence subsequent processing more broadly. Asking participants to answer yes or no (to the question of whether they found the target disgusting) also enables the same response labels to be used in a non-emotional assessment, thus ensuring that the two tasks are identical – with only a change to the task instructions.

With regard to stimuli, familiarity with the images likely decreases congruence effects, but it does not appear to do so sufficiently enough to prevent such effects from emerging (Neumann & Lozo, 2012). However, it may be the case that such familiarity can decrease interference from disgust primes in a perceptual task (an explanation consistent with the diminishing effects found after the first few blocks in van Hooff et al., 2013). The present experiment thus preserved stimulus novelty over the whole experiment by introducing a new set of stimuli (for both primes and targets) in each block.

Thus, two experimental tasks are presented in this chapter. The first is an emotional priming experiment where participants decided on whether they found disgusting, threatening and neutral stimuli to be disgusting after being exposed to both short and long primes of the same three emotional categories. The second is a non-emotional task, where participants were instructed to make an evaluation based on non-emotional criteria (the number of colours). The contribution of both disgust propensity and sensitivity is central to the hypothesis and is examined, as is attentional control (for its role in potentially moderating priming effects as discussed in chapter five).

6.2. Method

6.2.1. Participants.

Thirty-two participants (between the ages of 18 and 55) were recruited for this study, with three excluded due to excessively slow collapsed average RT (each were over 1.5 multiples of the interquartile range above the upper quartile and all had an average RT in excess of 1300 ms). This resulted in 29 retained participants; of these, 20 were female and 25 were right handed. The mean age for the sample was 28.14 (*SD* = 9.18).

6.2.2. Stimuli.

A total of 108 images were selected (36 each of disgust, fear and neutral scenes). The disgust stimuli included images of exposed guts and entrails, mud and faeces, dirty toilets, vomit, and rotted animal corpses. The fear stimuli contained images of snakes, alligators, sharks, guns, and aggressive dogs. All of the neutral images were taken from IAPS and depicted everyday objects.

For the masking procedure, 18 visual pattern masks were created in MATLAB by outputting a random selection of white or black pixels from a 256 x 192 array that was then stretched to the 1024 x 768 resolution used in the experiment.

6.2.3. Emotional decision task.

The experiment consisted of three blocks of 81 trials, with a short break in between each block. Half of the images were used as primes, with the other half used as targets. This arrangement was reversed for half the participants – a counterbalance to prevent effects related to unintentional biases between the prime and target sets. In order to preserve novelty over the experiment, each block used a unique set of stimuli and contained three primes and three targets from each emotional category which were fully crossed within each block (so that each of the nine primes were combined with each of the nine targets once).

For each trial, participants saw a fixation cross, followed by a prime image that was forwards and backwards masked and then a target image that they were instructed to respond to (see Figure 2). There was a 500 ms interval between trials. Of the 18 pattern masks, half were used as forward masks and half as backwards, with each combination of masks occurring once within each block and each mask being associated with each prime and target emotional category an equal number of times over the experiment. Participants were asked to indicate as quickly as possible whether the target image evoked the sensation of disgust or not using a "yes" or "no" response label that was counterbalanced across participants. For each prime image, the duration was varied from either a brief 40 ms display or an extended 250 ms display, with the presentation time randomised from trial to trial within blocks. Each prime image was presented with a long and short duration an equal number of times and the combinations of prime and target associated with short or long prime durations were reversed for half the participants so that each combination of prime and target image was presented with a short or long prime duration an equal number of times across participants.

Before the main task blocks, participants completed a short practice block, which consisted of eighteen trials (identical in structure to the main trials) encompassing three unique (i.e. not used in the main set) prime images (one each of disgust, fear and neutral) combined with six unique target images (two each of disgust, fear and neutral), with the primes presented for short durations in half the trials.

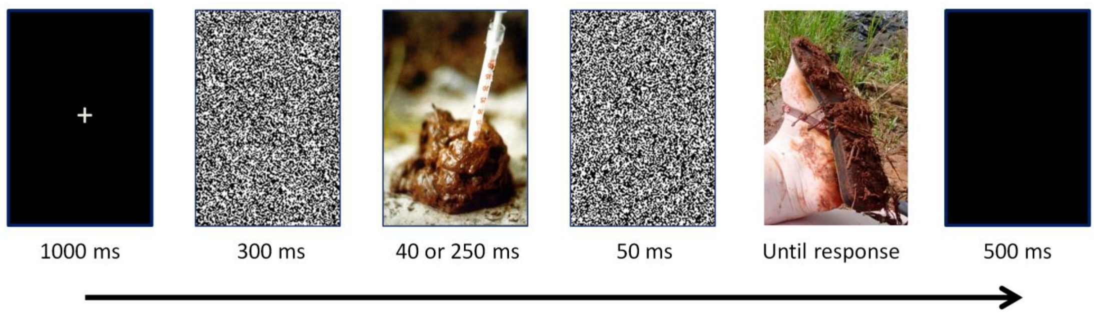

Figure 2. Experimental paradigm. A prime (of either short or long duration) varied between disgust, fear or neutral and was forwards and backwards masked. A target stimulus (varying between disgust, fear and neutral) followed and remained on screen until participants made a decision.

6.2.4. Non-emotional decision task.

The non-emotional decision task was identical to the emotional one, with only the task instructions changing. In this task, participants were instructed to estimate as quickly as possible (without actually counting) whether the target image contained many distinct colours or not (with many colours defined as more than three and different shades of the same colour not counting as multiple colours). The stimuli for this task were distinct from the emotional decision task, but were composed of the same overall disgusting, threatening and neutral categories. Prior to the experiment, stimuli were identified that represented colourful stimuli (with more than three distinct shades) and one third of each stimuli category contained such stimuli – thus using the same proportion of targets assumed to be assessed with a "yes" response as the emotional decision task (where one third of the targets were disgusting), and ensuring that these colourful stimuli were balanced across targets. Half the participants began with the emotional decision task, while the other half began with the non-emotional one (with the practice block requiring the same decision as the first task).

6.2.5. Rating task and individual difference assessments.

Following the tasks, participants rated the stimuli – using a procedure identical to the one outlined in chapter five (though using all the stimuli in the tasks of this experiment). Measures of disgust propensity and sensitivity were taken from the DPSS-R, with subdomain scores representing core, contamination and animal reminder disgust also obtained from the DS-R. Markers of both attentional focus and shifting were taken from the ACS.

6.3. Results

6.3.1. Pre-processing and results strategy.

Prior to analysis, RT means were computed for each participant (collapsed across all prime and target combinations). Trials with responses falling 2.5 standard deviations away from that participant's mean were excluded as were all trials with a response time of less than 200 ms, and the first five trials of each block. Average reaction time was calculated for each prime and target combination (nine combinations in all). The proportion of *disgusting* responses given by participants was also calculated for each combination with an arcsine square root transformation performed. Thus, for both the emotional and the colour evaluation tasks, RT was used as the dependent variable, and there was an additional analysis of the transformed response data for the emotional task.

Separate analyses were conducted for disgusting and threatening stimuli – with both compared against neutral prime and target combinations. Thus, the primary analysis was a linear mixed model ANOVA with prime (disgust/fear vs. neutral) and target (disgust/fear vs. neutral) entered as within-subject fixed effects and the four questionnaire variables entered separately as continuous variables. As the DS-R is considered to be an assessment of disgust propensity (rather than sensitivity), results relating to the three subdomains of this questionnaire were only analysed following significant priming effects related to the propensity score in the DPSS-R. This was accomplished in the form of a full multiple regression with all of the DS-R subscales used as predictors on the relevant outcome measure. Thus, examination of the DS-R had the purpose of elucidating the overall disgust propensity results. This same analytical approach was used for the analysis of the emotional decision task RT, emotional decision task response data, and non-emotional decision task RT.

6.3.2. Emotional decision task RT.

Means of both RT (in both tasks) and transformed response proportions (in the emotional decision task) for short and long primes can be found in Table 5.

Table 5. RT (*SD*) and transformed response proportions (*SD*) for trials with short and long primes for every prime and target combination in both emotional and non-emotional tasks.

	Emotional task				Non-emotional task	
	Short primes RT	Long primes RT	Short primes response	Long primes response	Short primes RT	Long primes RT
Disgust primes						
Disgust targets	719.47 (167.86)	699.93 (171.21)	1.16 (.35)	1.16 (.40)	693.66 (104.83)	740.17 (160.29)
Fear targets	716.72 (190.00)	721.71 (189.36)	.33 (.40)	.39 (.40)	708.00 (114.26)	721.51 (140.77))
Neutral targets	669.16 (146.60)	641.02 (136.48)	.06 (.12)	.11 (.22)	692.08 (141.60)	682.96 (104.12)
Fear primes						
Disgust targets	724.15 (160.69)	718.70 (183.80)	1.14 (.36)	1.19 (.39)	722.52 (151.40)	709.96 (144.25)
Fear targets	712.76 (157.06)	709.80 (196.03)	.35 (.38)	.33 (.39)	706.86 (120.43)	711.40 (137.87)
Neutral targets	665.17 (153.49)	640.18 (139.34)	.04 (.09)	.06 (.10)	673.91 (125.82)	677.26 (111.10)
Neutral primes						
Disgust targets	712.55 (156.15)	700.32 (144.20)	1.16 (.38)	1.18 (.38)	705.93 (118.95)	704.42 (148.06)
Fear targets	718.98 (187.13)	693.64 (166.34)	.32 (.39)	.32 (.39)	709.89 (122.04)	703.32 (111.95)
Neutral targets	663.38 (177.53)	652.82 (139.51)	.04 (.08)	.05 (.11)	676.78 (114.28)	700.71 (175.98)

6.3.2.1. Disgust targets.

The main prime x target x duration analysis revealed a main effect of target ($F(1, 28) = 24.87$, $p < .001$) with slower responses to disgust targets than to neutral targets, but there was no effect of primes or interaction (*F*s < 2.91, all *p*s > .09). With disgust propensity entered into the model, there was a significant prime x target x propensity interaction ($F(1, 28) = 9.04$, $p = .003$) with faster RT to disgust targets following disgust primes as propensity increased. There was also a prime x target x disgust sensitivity interaction ($F(1, 28) = 4.99$, $p = .027$) in the same direction. An index of the RT difference for disgust targets that were preceded by disgust or neutral primes was created (RT to disgust primes minus RT to neutral primes) and this was correlated with disgust propensity and sensitivity both for trials with short and long primes separately. For long primes, this index was significantly negatively correlated with both disgust propensity ($r(27) = -.53$, $p = .003$) and sensitivity ($r(27) = -.44$, $p = .016$) – see Figure 3. There were no significant correlations with disgust propensity ($p = .067$) or sensitivity ($p = .12$) for the trials with short primes. There were no effects related to attentional focus (all *F*s > 2.31, all *p*s < .13) or attentional shifting (all *F*s > 2.18, all *p*s < .14).

As there was an interaction with disgust propensity, further analyses were conducted on the subscales of the DS-R. As disgust propensity correlations were only significant for trials with long primes, further analyses were also carried out using these trials only. The RT discrepancy for disgust targets that were preceded by disgust over neutral primes (i.e. the difference score used for the correlations) was used as the dependent variable in a full multiple regression model, with core, animal reminder and contamination DS-R subscales as the independent variables. Tests of collinearity indicated that multicollinearity was not a concern (core disgust, tolerance = .57, VIF = 1.75; animal reminder disgust, tolerance = .59, VIF = 1.70; contamination disgust, tolerance = .76, VIF = 1.32). The model explained a significant proportion of the variance ($F(3, 24) = 6.44$, $p = .008$, $R^2 = .436$, adjusted $R^2 = .368$). Of the DS-R variables, only core disgust was a significant predictor ($\beta = -.48$, $t = 2.43$, $p = .022$), with animal reminder disgust ($p = .15$) and contamination disgust ($p = .56$) being non-significant.

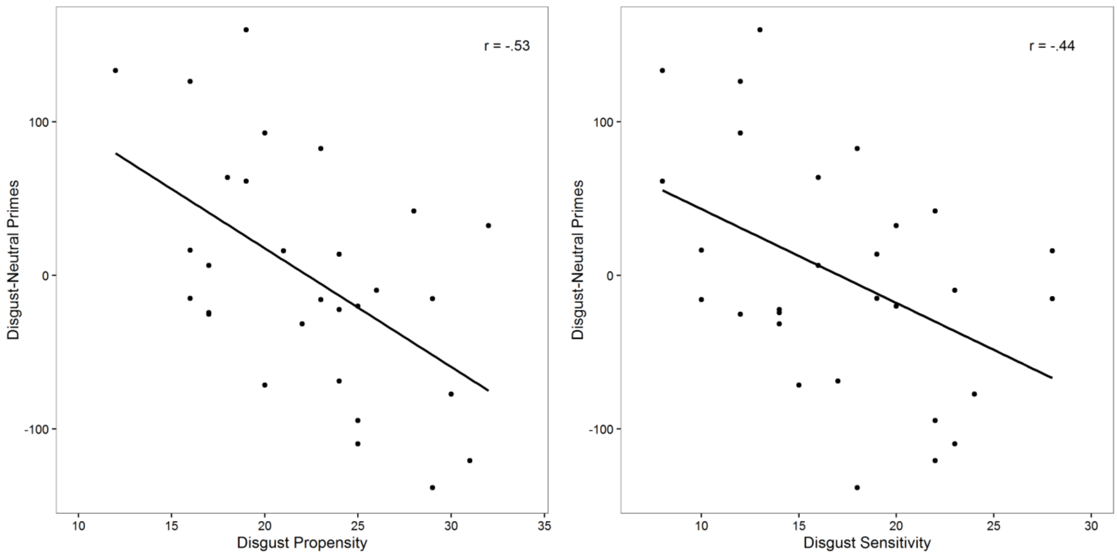

Figure 3. Correlations between the index representing the RT difference for disgust and neutral primes (disgust-neutral) for disgust targets (with long primes) and disgust propensity and sensitivity.

6.3.2.2. Fear targets.

There was a main effect of target (*F*(1, 28) = 33.13, *p* < .001) with increased disgust responses for fear targets, but no prime effect or interaction (*F*s < 2.96, all *p*s > .09). There was a target x propensity interaction (*F*(1, 28) = 6.15, *p* = .014) with slower responses to fear targets with increasing propensity; but pivotally, there were no effects related to priming. There were no effects related to disgust sensitivity (all *F*s < 2.78, all *p*s > .10), attentional control (all *F*s < 1.39, all *p*s > .24) or attentional shifting (all *F*s < 1.03, all *p*s > .31).

6.3.3. Emotional decision task response.

6.3.3.1. Disgust targets.

There was an expected enhancement in disgust assessments for disgust over neutral targets (*F*(1, 28) = 1472.79, *p* < .001), but no priming effect or interaction (*F*s < .85, all *p*s > .36). There was a highly significant interaction between target and disgust propensity (*F*(1, 28) = 43.99, *p* < .001) with increased disgust assessments of disgust targets with increasing propensity. There was a similar interaction (in the same direction) with target and disgust sensitivity (*F*(1, 28) = 77.56, *p* < .001). There was an interaction between target and attentional focus (*F*(1, 28) = 16.15, *p* < .001) with a reduced number of disgust responses to disgust targets as focus increased. There were no effects related to attentional shifting (all *F*s < .76, all *p*s > .39).

6.3.3.2. Fear targets.

There was a main effect of target (*F*(1, 28) = 107.94, $p < .001$) with more disgust responses to fear than to neutral targets; there was no priming effect or interaction (*F*s < .16, all *p*s > .69). There were no effects related to disgust propensity (all *F*s < 1.13, all *p*s > .30). There was an interaction between target and disgust sensitivity (*F*(1, 28) = 63.09, $p < .001$) with a greater number of disgust responses to fear targets with increasing sensitivity. There were no effects related to attentional focus (all *F*s < .22, all *p*s > .64) or attentional shifting (all *F*s < .42, all *p*s > .52).

6.3.4. Non-emotional decision task RT.

6.3.4.1. Disgust targets.

There was a significant prime x target x duration interaction (*F*(1, 28) = 5.41, $p = .021$) with slower responses to disgust targets that followed disgust primes that were long in duration. There were no effects related to disgust propensity (all *F*s < 2.70, all *p*s > .10), disgust sensitivity (all *F*s < .90, all *p*s > .34), attentional focus (all *F*s < 1.81, all *p*s > .18) or attentional shifting (all *F*s < 1.10, all *p*s > .30).

6.3.4.2. Fear targets.

There was a main effect of target (*F*(1, 28) = 9.02, $p = .003$) with slower responses to fear targets, but no prime effect or interaction (all *F*s < .86, all *p*s > .36). There were no effects related to disgust propensity (all *F*s < 1.37, all *p*s > .24), disgust sensitivity (all *F*s < 1.73, all *p*s > .19) or attentional focus (all *F*s < 1.96, all *p*s > .16) or attentional shifting (all *F*s < 2.66, all *p*s > .10).

6.3.5. Rating task results.

The procedure for the rating task was identical to the one described in chapter five, but used all of the stimuli (across both tasks) for the present experiment. Overall means and standard deviations are presented in Table 6.

Table 6. Mean (*SD*) ratings for the levels of disgust, threat and pleasantness for each stimuli category.

Ratings	Disgust	Fear	Neutral
Disgusting	5.57 (1.40)	2.42 (1.29)	1.21 (.52)
Threatening	2.25 (1.25)	4.41 (1.64)	1.22 (.52)
Pleasant	1.48 (.58)	2.80 (1.35)	4.21 (1.52)

6.4. Discussion

The results for the tasks in this chapter suggest that priming mechanisms can emerge specifically for disgust but that this is contingent on higher levels of disgust propensity and sensitivity. For the emotional decision task that required participants to explicitly decide upon whether target stimuli were disgusting or not, there were no main priming effects – with effects only manifesting once trait disgust measures were analyzed. Both disgust propensity and sensitivity were associated with faster response times to disgust targets that followed disgust primes – an effect that was not present when fear stimuli were used in place of disgust. In the non-emotional decision task (where participants were required to assess the colours of the target), response times were slower for disgust targets that followed disgust primes – an effect that appeared not to be related to differences in trait disgust or attentional control, and one that did not emerge for fear stimuli. In the emotional decision tasks, both disgust and fear targets were associated with slower RT than neutral targets (regardless of prime). The proportion of disgust responses was higher for both disgust and fear targets than neutral. For disgust targets, this proportion increased with disgust propensity and sensitivity, but decreased with higher levels of attentional focus. For fear targets, disgust sensitivity was uniquely associated with an increased proportion of disgust assessments. These results will be discussed individually with a focus on the results relating to priming effects.

6.4.1. Priming effects in the emotional task.

The main hypothesis that measures of disgust propensity or sensitivity would result in an enhanced congruence benefit for disgust prime/target combinations that was not present for fear equivalents appeared to be confirmed. Because this task used a response option that specifically targeted disgust – rather than one that targeted multiple emotional categories – it is difficult to directly compare these results with others in the literature that have found an emotional congruence effect. However, these results do appear to be in line with the semantic activation theories (discussed by Neumann & Lozo, 2012, and Rohr et al., 2012) and adds to them with the suggestion that when experiments target one particular emotional label, congruence effects appear to only emerge for this category. This may indicate that it is not simply the prime and target combination that brings out the observed processing benefit, but that the response label itself enables such a congruence benefit to emerge from the processing of the stimuli. Individual differences in levels of disgust have been shown to moderate not just the influence of disgust exposure, but also the extent to which disgusting information can influence processing (see chapter three); these results demonstrate that trait disgust moderates visual priming influences. Interestingly, disgust propensity and sensitivity appeared to predominantly influence priming for trials where the primes were on screen for long enough to typically be considered supraliminal (with significant correlations only for trials with long primes), which would suggest that these measures exert a disproportionate effect on disgust priming when the disgusting information is fully consciously processed.

Disgust exposure is associated with numerous behavioural influences, but it may be that the conscious processing of disgusting information is required to bring out these effects – simply presenting disgusting information beneath the level of awareness may be less consequential. It is possible that ongoing perception may be altered as a result of merely detecting disgusting information – a mechanism that could be adaptively useful (for example in preparing individuals to detect other contaminating stimuli in an environment) – however, this experiment suggests that disgust's influence on ongoing behaviours appears to be more contingent on this information being consciously or affectively processed. Implicit influences on processing have been detected from fear stimuli (Öhman, Flykt, & Esteves, 2001), and such implicit detection likely confers an adaptive advantage as a fear response may be needed to provoke a fast avoidance reaction from potentially life endangering entities. The unusual (relative to the other basic emotions) pattern of physiology associated with disgust does not stimulate such fast active avoidance (see chapter 3.4.1), and as a result the influences from disgust may be contingent on more evaluative processes. Using a different paradigm, Cisler and Olatunji (2010) found that individuals higher in contamination fear experienced difficulty disengaging from disgust (and fear) stimuli that were on screen longer. The results here suggest that extended durations of visually presented disgust stimuli also facilitate enhanced emotional priming effects for those higher in disgust propensity and sensitivity – thus further highlighting the importance of presentation times in enabling effects associated with aversive emotional exposure.

Alternatively, as disgust has been represented as an emotion high in ambiguity (Douglas, 1966/2003), it is possible that the failure to find strong evidence for priming effects using short (relative to long) primes in this experiment (or in chapter five) is due to disgusting stimuli being difficult to process under such brief exposure conditions. Although Rohr and Wentura (2014) found that discrimination at the level of the emotional category was dependent on conscious processing of the primes, Neumann and Lozo (2012) found subliminal congruence effects for both disgust and fear stimuli using primes of equivalent duration to the short primes in this study (thus suggesting that it is not a failure to process disgusting information at such short presentation times that is driving these effects). As the range of stimuli, and the response required from participants, varied between these previous studies (and with this one) it is difficult to interpret such discrepant results. However, the results of Neumann and Lozo (2012) do certainly indicate that disgusting stimuli can be detected (to a similar degree as to fear) under subliminal conditions when the task hinges on emotional identification and requires a binary emotional classification of a set that includes only two types of stimuli (disgust and fear). These subliminal priming effects would appear to be diminished when an expanded set is used and when the response option targets specifically disgusting stimuli.

The results of this experiment provide evidence that the capacity for disgust propensity and sensitivity to facilitate priming effects that are specific to disgust may be dependent on the primes being on screen for an extended duration. As a caveat, given that the main trait disgust analyses in chapter 6.3.2.1 did not interact with prime duration, and the correlation with disgust propensity for short primes could be considered to be tending towards significance, it is possible that trait disgust can impact more subliminal priming influences (albeit to a substantially lesser degree) within this paradigm and may be worth investigating in future experiments. However, overall the evidence from this experiment clearly indicates that disgust propensity and sensitivity more strongly facilitate disgust priming influences when primes are extended.

6.4.2. Priming effects in the non-emotional task.

The only priming effect in the non-emotional task was a significant slowing of response to disgust targets preceded by disgust primes. This effect was not present for fear stimuli (which generally slowed responses compared to neutral targets, regardless of prime), and only manifested when the disgust primes were on screen for longer. Although emotional appraisal could be necessary to bring out processing effects related to disgust (Hartigan & Richards, 2016), more generally aversive stimuli are associated with disruptions to processing – even in cases where attention is explicitly directed at another task (van Hooff et al., 2013, 2014). These latter two studies also suggested that interference with ongoing processes at particular time intervals does seem to be more potent for disgust than fear stimuli; as a result, it may not be surprising that it was the disgust stimuli that produced this effect. This is especially true as the effect only emerged for longer primes. Fear stimuli are associated with a rapid detection and disengagement, so the increased duration of the long primes may have prevented fear stimuli from disrupting decisions that occurred after an increased interval.

That this response time slowing only manifested with congruent disgust primes and targets may suggest that the tendency to more easily detect a stimulus of the same emotional category as a result of a prime (i.e. the processing bias that drives emotional congruence effects) actively disrupted the non-emotional assessment of the images. Under this interpretation, these results are evidence of an emotional congruence effect influencing processing even when emotion is not explicitly under consideration. Alternatively, this could simply be evidence of a general disruptive effect from disgust stimuli that only manifested as a result of repeated (and consciously processed) presentations. Under this account, there is simply a short-term cumulative effect of viewing disgust images that can impair processing (of another task). The long trials presented two distinct successive disgust images that were fully processed, whereas the short trials may have prevented the first image (the prime) being consciously processed – resulting in insufficient interference with the task. Both these accounts are consistent with the results, though there is no evidence from elsewhere that suggests that disgust's influence on processing is contingent upon repeated presentations; other studies (van Hooff et al., 2013, 2014) have found significant processing effects from a single disgust stimulus (albeit using a different paradigm that likely taps slightly discrepant perceptual and attentional processes), so the latter interpretation seems less likely. Further investigation should be made into implicit priming effects using non-emotional assessments to elucidate this finding.

6.4.3. Target response effects in the emotional task.

Both the disgust and fear target stimuli were consistently associated with slower RT and more disgust responses than neutral targets regardless of primes. The RT finding is not surprising as emotional stimuli may require more processing resources than non-emotional stimuli. The finding that fear stimuli was regarded as disgusting more often than neutral stimuli is also not unexpected – though fear stimuli were selected that provoked minimal levels of disgust, it is virtually impossible to create a fear set that would be rated equivalently in disgust to neutral stimuli. Given that the disgusting stimuli were classed as disgusting substantially more often than fear (see Table 5) and rated higher in disgust (see Table 6), these stimuli were clearly appraised as more disgusting by participants. However, a smaller proportion of the fear targets did appear to be classified as disgusting in the task (albeit with a high degree of variability across participants).

As with Chapter five, disgust propensity and sensitivity were both associated with increasing disgust classifications of disgusting stimuli. More interesting was that fear stimuli were increasingly classified as disgusting as disgust sensitivity (but not propensity) increased (an effect may also have been partially responsible for the substantial variability in fear classifications). Although disgust sensitivity refers to the unpleasantness experienced when coming into contact with disgusting stimuli, it has been found to be associated with emotional sensitivity in general (Goetz et al., 2013; Olatunji, Moretz, et al., 2010) and could provoke a more emotional response to all aversive stimuli that simply manifested through increased disgust classifications given it was the only emotional response option. Alternatively, as disgust sensitivity is associated with the initial detection and experience of disgust – rather than being associated with the streamlining of disgust stimuli for further processing as disgust propensity is (Borg et al., 2012) – it is possible that in a priming task (where assessments are made as fast as possible) disgust sensitivity may be associated with a misclassification (relative to the classification that would be given without such time constraints) of an increased proportion of fear targets. These interpretations would require specifically constructed paradigms to evaluate further, but it is worth noting that this was the only finding in the experiment where disgust sensitivity was exclusively associated with an outcome measure.

6.4.4. DS-R subscale influences.

The DS-R was included in this experiment in order to examine whether specific effects that emerged for disgust propensity were exclusively related to one particular subscale in the DS-R. The multiple regression analysis revealed that core disgust was the only significant predictor of the RT priming effects. It is difficult to speculate a priori which subscales of the DS-R should be affected by the disgust stimuli in this experiment – though arguments can clearly be made that the other two subscales should influence the perception of the specific stimuli used. For example, given that many of the disgust stimuli were images that should be relevant to contamination concerns (such as dirty toilets and exposed entrails), contamination disgust in particular could have been expected to influence the results. However, given that only core disgust was associated with disgust priming, this may simply be evidence that these priming effects are driven by a generalised disgust propensity domain (which more closely maps to core disgust than either of the other DS-R subdomains). The subject of generalised disgust propensity (as a variable relevant to the broader results in this thesis) is one discussed in more detail in 10.3.1.2; however, for this experiment, the results would appear to preclude animal reminder or core disgust as variables relevant to disgust priming effects. It may be valuable for future research to examine this in more detail by determining whether the disgust related priming effects found in this study can be driven by individual differences in specific DS-R subdomains if a very narrow and targeted range of elicitors are used as stimuli, but this chapter suggests that for more general disgust stimuli sets, broader disgust propensity may be a more important variable for predicting individual differences in disgust priming.

6.4.5. Conclusion.

The results in this chapter demonstrated that a disgust congruence benefit could emerge in individuals high in disgust propensity and sensitivity, particularly for prime durations long enough to be consciously processed and when participants were explicitly evaluating the images for disgust. There was also evidence that disgust targets following disgust primes had the potential to slow responses when participants were engaging with the non-emotional aspects of the images thus potentially indicating that disgust prime and target congruence disrupts processing of another task. While this latter effect was not expected, the primary hypothesis of this experiment was confirmed and evidence was provided that trait disgust can enhance disgust congruence priming.

Chapter 7. Does Affective Exposure to Disgust Influence Responses to Food Images?

7.1. Introduction

The research presented in Chapter six established that disgust priming resulted in a congruence benefit for individuals with high disgust propensity and sensitivity. However, chapter five failed to find any modulation of food images as a result of brief disgust primes. Given that the results of chapter six point to a greater effect from supraliminal primes, it may be that conscious processing of disgust is required to bring out such effects. Disgust is found to have numerous effects when it is induced using methods that are similar to mood manipulations (see chapter 3.2.1), and many of the most influential studies linking disgust exposure and moral judgement have used methods that are akin to this (see chapter 3.3.1). The experiment presented in this chapter examines whether a more sustained and affective disgust manipulation would influence the processing of food images. As the central question is whether food images can be influenced by disgust exposure, paradigms influenced by effects such as emotional congruence may not be most appropriate for examining this. Thus, a different paradigm was constructed to address this question.

The goal of the research in this chapter was similar to that of chapter five – in that the concern was specifically whether food images that would otherwise be regarded as pleasant could be influenced by disgust. While studies have examined responses to unpleasant food images (see chapter five), the extent to which disgust has the capacity to contaminate otherwise pleasant food images requires investigation. If disgust has the capacity to put people off consuming food, then otherwise pleasant food is the most relevant stimuli to investigate. The IAPS food images used in chapter five are rated as pleasant (according to the normative valence ratings) and were rated as pleasant by participants in the actual experiment. Thus, a similar set was selected in this experiment (but with the inclusion of additions from other online image sources).

These food images would be ordinarily expected to be classified as pleasant by participants, but this experiment tested the hypothesis that individuals exposed to disgust would either classify fewer of them as pleasant compared to a neutral exposure control group, or would do so slower. If participants are required to decide whether images are unpleasant or not as quickly as possible, then (if disgust has the capacity to influence the perception of food) exposure to disgust could potentially be associated with a hesitation for food images that is not present for other pleasant stimuli. Given that the expectation was that food images would still predominantly not be classified as unpleasant (as these stimuli are not typically regarded as such), an increased response time to food images may be the domain in which such exposure effects manifest. Thus, a paradigm that encouraged participants to respond quickly (similarly to a priming study) was constructed – with the hypothesis that if exposure effects manifested, they would slow responses to food images. The task in this chapter required participants to decide whether food images, general pleasant images (similar in qualities to the ones in chapter five) and disgusting images were unpleasant or not as quickly as possible. The disgusting images were predominantly included in order to ensure that some of the images would be regarded as unpleasant (so as to prevent participants from simply indicating that each image was not unpleasant), though responses to these images were also included in the analysis. Thus, the experiment functioned as a rapid binary response task (comparable to those in chapter five or six) but using only target images. A similar paradigm, following an emotion manipulation, but using ambiguous stimuli, has been proposed recently as a measure of implicit emotions (Bartoszek, 2016, Bartoszek & Cervone, 2016). Although the stimuli used in this chapter are not explicitly ambiguous, responses to pleasant food stimuli may still be affected by such an emotional manipulation if disgust has the capability to influence the desirability of edible items.

The experiment reported in this chapter used written scenarios as a method of disgust induction. The approach was similar to the one taken by van Dillen et al. (2012). One particular advantage of inducing disgust in this way is that it allows for the construction of a task where participants are required to recall the disgusting scenarios they were presented with. This ensures that participants cannot fully disengage from the disgust manipulation and are required to reflect on it (at least to some extent) throughout the task.

Measures of disgust propensity and sensitivity, as well as attentional focus and shifting were also taken from each participant. The link between trait disgust and disgust exposure has been discussed previously (see chapter three), as has the link between trait disgust and food consumption (see chapter five). It is entirely possible that if exposure effects emerge, they are entirely bound with trait disgust measures (as they were in chapter six), rather than manifesting more generally. Thus, this experiment also examines whether disgust propensity and sensitivity are necessary for such exposure effects to emerge. Measures of attention were included as disgust induction through written scenarios was strongly influenced by attentional control in van Dillen et al. (2012). While attentional focus may be a relevant variable for overriding the effect of a disgust manipulation more generally such that the classification task can be engaged with more easily, attentional shifting may also be important – as requiring participants to remember written scenarios may effectively form a second task that requires a temporary attentional shift in order to fully engage with the main emotional assessment task.

In addition to the main analysis, which contrasted food and otherwise pleasant image responses between exposure groups, the lack of visual priming influences (including the emotional congruence confounds that prohibited analysis of stimuli categories other than food in chapter five) enables the examination of responses to other targets as a function of disgust exposure. In particular, disgusting stimuli are of relevance. It seems plausible that exposure to disgust would lead to a faster or more consistent classification of disgust stimuli – this would represent a congruence effect, but of a more cognitive and affective nature than the congruence effects that emerge from visual priming. Given previous mood manipulation studies (see chapter 3.2.1), this result would be expected; however, it is instructive to examine whether such an effect is connected to trait disgust measures. If disgust propensity or sensitivity moderates not just visual priming influences specifically associated with processing disgust images (as was found in chapter six) but also more affective mood related disgust exposure influences on such stimuli, it would have implications for the ways in which these personality measures affect ongoing disgust processing following the initial experience or perception of disgust. Thus, in addition to the main food analysis, the influence of disgust exposure on responses to disgust target stimuli was also examined.

As the disgust exposure in this experiment was more sustained and affective in nature (than in the previous experiments), the effects of this exposure on the rating data for the stimuli was also examined. These images were assessed after participants had been exposed to a series of disgusting (or neutral) sentences throughout the experiment. This is instructive to examine as disgust manipulations of this nature have often produced effects using paradigms that tap more elaborative cognitive processes (such as the moral assessment tasks) that do not rely on response time data or classification errors. Given that the previous rating tasks (in chapters five and six) have encouraged participants to take their time while assessing each image, analysing whether the exposure condition influences these ratings provides a marker of the extent to which disgust can contaminate consciously appraised explicit assessments of stimuli. Another good reason to use this measure is that the binary unpleasant (or not) assessment of the stimuli used in the main task may not be sensitive enough to detect the influence of such exposure. Thus, this experiment examined the effects of disgust exposure on

RT, proportion of unpleasant responses, and disgust ratings for both food and disgusting scene images.

7.2. Method

Participants completed the main task followed by the ratings task (first images then sentences) and finally the questionnaires.

7.2.1. Participants.

A total of 38 participants (between the ages of 18 and 55) took part in this study; however, 10 were excluded from analyses. Two participants were excluded for accidentally reversing their response options at the beginning of the experiment (i.e. selecting "yes", rather than "no" consistently) – given that both of these participants stated that they switched to using the correct response options after they noticed this mistake, this alteration of response option ensured that their response data could not be simply reverse coded (as they were likely to be primed towards an opposite response key for the remainder of the experiment as a result of this – which could have influenced RT). Although no participants had an average RT value that was 1.5 multiples of the interquartile range above the upper quartile (the criterion used to exclude participants in chapters five and six), this was partly due to a large number of participants having excessively slow responses. Because of this, eight participants were excluded from analysis, all of whom had average RTs of above 1000 ms and more than 25% of their total responses above 1000 ms. All remaining participants had an average RT of less than 1000 ms. The remaining 28 participants had a mean age of 26.82 (SD = 9.17), 21 were female, and 25 were right handed.

7.2.2. Stimuli.

A total of 32 each of disgust, food and generally pleasant scenes were used in this experiment. The disgust stimuli included images of entrails and organs, mud and faeces, dirty toilets and vomit. The food stimuli set included images of fruit, vegetables, desserts (predominantly chocolate cakes), confectionery, eggs, pizza, pastries, and rice. As with chapter five, no meat or fish images were used. The pleasant images included flowers, plants and landscape scenes.

A total of 48 sentences were created – 24 each of disgusting and neutral control scenarios. The disgusting sentences were partly adapted from van Dillen et al. (2012), but they were also adapted from items in the DS-R questionnaire (as it was not used in this experiment). The disgusting sentences were phrased in the second person and described a disgusting experience that one could encounter. These 24 disgust sentences represented 12 elicitors – with two sentences being associated with each elicitor. The elicitors were ant infestations, cockroaches, used condoms, lice, maggots, mould, mucus, rats, slugs, skin spots, urine and filthy water. In order to ensure that none of the results were based on familiarity effects with the elicitors, none of these elicitors were embodied by the images (i.e. the elicitors for the disgust images were distinct from the elicitors in the disgust sentences). For each disgust sentence, a corresponding neutral sentence (matched for the number of syllables) was also created; these sentences depicted similar scenarios, but with the disgust elicitor replaced by a neutral substitute – for example, one scenario depicting stepping on cockroaches after coming home is replaced by stepping on some post. See Appendix B for the full list of disgust and neutral sentences.

7.2.3. Main task procedure.

Each participant was assigned to either the disgust or neutral exposure group upon arriving for the experiment. Half of the total participants were assigned to each group, but after exclusions this resulted in 15 participants in the disgust exposure group, and 13 in the neutral exposure group.

The experiment consisted of four blocks of 48 trials each. Participants were instructed to view the images and decide as fast as possible whether each was unpleasant or not (using a "yes" or "no" response option that was counterbalanced across participants). Each block consisted of two consecutive cycles of 24 trials (eight each of disgust, food and pleasant), with each cycle randomised (so that no image appeared in the first or second half of the block twice). Each block used a different set of stimuli, and the order of the blocks was reversed for half the participants. The trials began with a 1000 ms fixation cross, followed by the image that remained on screen until a response was given, this was followed by a blank screen for 1000 ms.

Before each block, participants were presented with three sentences to read and remember. These sentences were presented sequentially and remained on screen until the participants pressed a key. After each block, participants were presented with six sequential sentences and ask to indicate whether each one was familiar or unfamiliar. Three of these sentences were the ones participants had been presented with before the block, while the other three were unfamiliar but included the same elicitors as three that were familiar (so that participants could not identify the correct sentence simply by identifying the elicitor). As each elicitor was present in two sentences, one counterbalance was to ensure that each sentence appeared as a sentence to remember for half the participants, and as a sentence in the recall task only for the other half. The neutral exposure condition was identical (including being subject to the same counterbalance) with the exception that matched neutral sentences were used in place of the disgust sentences. The overall recall across the two groups was extremely high (97% correct identification; note that due to a programming error, the first seven participants' recall was not recorded); but as this task was merely to ensure that participants were reflecting on the scenarios, this was not subject to further analysis.

7.2.4. Rating task procedure.

The ratings task was identical to those presented in chapters five and six. In addition to the images, all sentences (both neutral and disgusting) were rated by each participant (on a 7-point scale) for how disgusting they were. The DPSS-R and the ACS were completed after the rating task.

7.3. Results

Means for both RT and transformed response proportions (for all stimuli in both conditions) are presented in Table 7; as this was a between-subject experiment (and the ratings data was used in the analysis), the rating results for both groups are also presented here. The disgust sentences were rated as 5.59 (*SD* = .90) for disgust in the disgust exposure group and 5.85 (*SD* = .45) in the neutral exposure group; conversely, the neutral sentences were rated as 1.60 (*SD* = .69) in this disgust exposure group and 1.72 (*SD* = .99) in the neutral exposure group.

Table 7. Mean (*SD*) for RT, transformed response proportion, and stimuli and sentence ratings (all categories) for both exposure groups.

	Disgust	Food	Pleasant
Disgust exposure			
RT	667.27 (118.89)	678.95 (117.10)	611.69 (123.84)
Response	1.40 (.12)	.15 (.13)	.05 (.08)
Disgusting rating	5.27 (1.24)	1.69 (.62)	1.17 (.25)
Threatening rating	2.83 (1.96)	1.25 (.43)	1.25 (.22)
Pleasant rating	1.45 (.51)	5.25 (.68)	6.18 (.60)
Neutral exposure			
RT	661.28 (135.36)	680.59 (142.65)	619.89 (142.63)
Response	1.36 (.08)	.21 (.20)	.12 (.08)
Disgusting rating	5.65 (.71)	1.55 (.68)	1.31 (.47)
Threatening rating	3.58 (2.07)	1.38 (.75)	1.34 (.54)
Pleasant rating	1.40 (.37)	5.26 (.85)	5.89 (.85)

7.3.1. Pre-processing and results strategy.

As with the previous experiments, responses under 200 ms, as well as responses 2.5 standard deviations away from each participant's overall mean were excluded, as were the first five trials of each block. Average RT was calculated for each of three stimuli categories, as were the proportion of unpleasant responses (which were subject to an arcsine square root transformation). The primary analysis was an emotion (food vs. pleasant) x exposure group (disgust vs. neutral) mixed ANOVA. As with the previous experiments, there was an initial analysis followed by four additional analyses with inclusions of disgust propensity, disgust sensitivity, attentional focus and attentional shifting. In addition to this main analysis, in order to examine whether exposure influenced the responses to disgust, the same analysis was conducted again but using the contrast between disgust and pleasant results as the emotion variable.

7.3.2. Food and pleasant RT.

The main image x exposure analysis revealed a main effect of emotion ($F(1, 26) = 20.02$, $p < .001$) with slower RT to food targets; there was no condition effect or interaction (Fs < .12, all ps > .73). There was a significant emotion x exposure x disgust propensity interaction ($F(1, 26) = 2.42$, $p = .023$) with slower responses to food targets in the disgust exposure group with increasing propensity. There were no significant effects associated with disgust sensitivity, though there was a non-significant trend towards an exposure x sensitivity interaction (all Fs < 3.41, all ps > .08). A variable representing the difference in RT between food and pleasant images was created (food minus pleasant). In the disgust exposure group there was a trend towards a positive correlation with disgust propensity, but this was not significant ($r(13) = .47$, $p = .080$), there was also no significant correlation in the neutral exposure group ($r(11) = -.44$, $p = .13$). Although there was no significant correlation, it is interesting to note that the direction of the relationship differed between the groups; the significance of this difference was examined using Fisher r-to-z transformation, which revealed a significant difference between correlations ($z = 2.29$, p = .022). There was a significant emotion x attentional focus interaction ($F(1, 26) = 4.96$, $p = .036$) with slower responses to food targets as focus increases. There were no effects related to shifting (all Fs < 2.85, all ps > .10).

7.3.3. Food and pleasant responses.

The main image x exposure analysis revealed a main effect of emotion ($F(1, 26) = 4.32$, $p = .048$) with an increased unpleasant response to food targets; there was no condition effect or interaction (Fs < 3.07, all ps > .09). There were no effects related to disgust propensity (all Fs < .94, all ps > .34) or disgust sensitivity (all Fs < 1.73, all ps > .20). There was an interaction between exposure and attentional focus ($F(1, 26) = 4.30$, $p = .049$) with fewer unpleasant responses in the disgust condition as attentional focus increases; there was also an interaction between emotion and attentional focus ($F(1, 26) = 4.29$, $p = .049$) with increased unpleasant assessments to food images as focus increased. There were no effects related to attentional shifting (all Fs < 1.34, all ps > .26).

7.3.4. Food and pleasant ratings.

There were no main experimental effects (Fs < 1.47, all ps > .24). There was a significant emotion x exposure x disgust propensity interaction ($F(1, 26) = 8.49$, $p = .008$) with increasing disgust propensity ratings to food stimuli as disgust propensity increased. A difference index was created (food minus pleasant), and this value had a non-significant positive correlation with disgust propensity in the disgust exposure group ($r(13) = .45$, $p = .091$), but a significant *negative* correlation in the neutral exposure group ($r(11) = -.57$, $p = .040$). The significance of this difference was examined using Fisher r-to-z transformation, which revealed a significant difference between correlations ($z = 2.64$, p = .008). There were no effects related to disgust sensitivity, but there was a borderline non-significant emotion x exposure x disgust sensitivity effect (all *F*s < 3.97, all *p*s > .058). There were no effects related to attentional focus (all *F*s < .56, all *p*s > .46) or attentional shifting (all *F*s < 1.08, all *p*s > .31).

7.3.5. Disgust and pleasant RT.

The main image x exposure analysis revealed a main effect of emotion ($F(1, 26) = 6.14$, $p = .020$) with slower RT to disgust targets, but no condition effect or interaction (*F*s < .39, all *p*s > .54). There was an interaction between exposure group and disgust propensity ($F(1, 26) = -2.39$, $p = .024$) that was suggestive of a slower response in the disgust exposure group as disgust propensity increased (regardless of stimuli category). There were no effects related to disgust sensitivity (all *F*s < 3.68, all *p*s > .07) or attentional control (all *F*s < .074, all *p*s > .79). There was an interaction between emotion and attentional shifting ($F(1, 26) = 4.90$, $p = .037$) suggesting a relatively slower response to disgusting stimuli as shifting increases (though this could be interpreted as a faster response to pleasant stimuli).

7.3.6. Disgust and pleasant responses.

The main analysis revealed an interaction between emotion and condition ($F(1, 26) = 5.36$, $p = .025$) with increased unpleasant classifications for disgust images in the disgust condition. There were no effects related to disgust propensity (all *F*s < 1.00, all *p*s > .32), disgust sensitivity (all *F*s < 2.03, all *p*s > .16), attentional focus (all *F*s < 1.17, all *p*s > .29) or attentional shifting (all *F*s < 1.67, all *p*s > .20).

7.3.7. Disgust and pleasant ratings.

Unsurprisingly, disgusting images were rated as more disgusting than pleasant images ($F(1, 26) = 211.93$, $p < .001$), but there was no effect of exposure group or interaction (*F*s < 1.60, all *p*s > .22). There was a significant emotion x exposure x disgust propensity interaction ($F(1, 26) = 5.90$, $p = .023$) with increasing disgust ratings for the disgust stimuli in the disgust group with increasing levels of disgust propensity. A difference index was created by subtracting disgust ratings of pleasant stimuli from disgust ratings of disgust stimuli; there was a very strong correlation between this index and disgust propensity in the disgust exposure group (*r*(13) = .76, *p* = .001; see Figure 4), but no correlation in the neutral exposure group (*p* = .76). There were no effects related to disgust sensitivity (all *F*s < 1.68, all *p*s > .21), attentional focus (all *F*s < 1.02, all *p*s > .32) or attentional shifting (all *F*s < 2.35, all *p*s > .13).

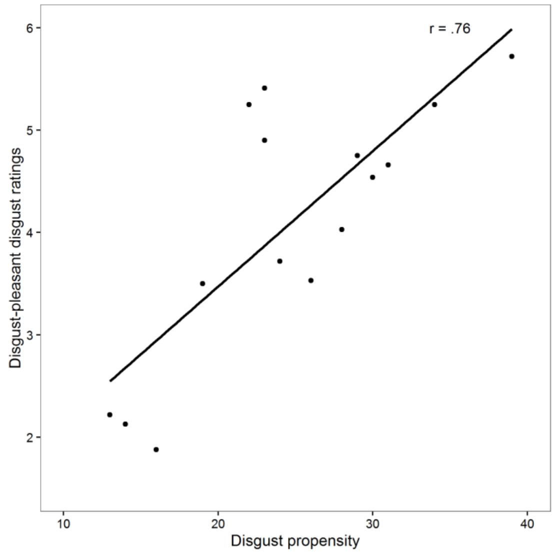

Figure 4. Correlation between the index representing the disgust increase for disgust over pleasant images in the disgust exposure condition.

7.4. Discussion

The primary aim of this experiment was to investigate whether disgust exposure could influence the processing of food images, and whether any such effect was related to individual differences in trait disgust or attentional control. The results suggested that exposure to disgust influences the processing of food images, but does so in conjunction with disgust propensity. While propensity did not influence the proportion of unpleasant assignments of the food stimuli (following disgust exposure), it did slow response time to these images. Explicit disgust ratings of the food stimuli also varied as a function of disgust propensity – with an increasing gap between the assessments of food and pleasant in the disgust exposure group and the opposite pattern in the neutral exposure group. Outside of interactions with stimuli and exposure, attentional focus was found to increase the classification speed of pleasant (relative to food) stimuli, and to reduce the proportion of unpleasant assignments as a result of being in the disgust condition overall. It was also associated with an increased proportion of unpleasant assignments of food stimuli (regardless of exposure group).

The second area of investigation in this experiment was to examine whether exposure to disgust influenced responses to disgusting stimuli (similarly to the emotional congruence effects in emotional priming and mood manipulation studies), and whether individual differences in trait disgust and attentional control could modulate this influence. An increased proportion of the disgust images were classified as disgusting following disgust exposure (an effect independent of trait disgust and attentional differences). Disgust propensity substantially increased the disgust ratings for the disgust images, but only amongst individuals who were exposed to disgust. Outside of exposure effects, disgust propensity was associated with a general RT slowing in the disgust exposure group and attentional shifting was associated with slower response to disgust images (relative to pleasant ones).

7.4.1. The influence of disgust exposure on the processing of food images.

The main hypothesis appeared to be confirmed (although the predicted effect appeared only to manifest amongst individuals with increasing levels of disgust propensity). As disgust propensity increased, slower responses to food stimuli (relative to pleasant) were observed. A similar pattern was found in the rating data for the food analysis, though it is worth noting that the pattern of results for the neutral exposure group suggested that disgust propensity actually reduced disgust assessments in this condition (and may have partly driven this effect). This finding appears to represent an increased baseline for disgust assessments as a result of disgust propensity (so that even the disgust assessments of pleasant stimuli was marginally increased), but increasing levels of disgust assessments of food only in the disgust exposure group. Although the statistically significant difference in direction between the correlations support this interpretation (and is the same pattern as the RT results), it may be worth investigating these specific effects more in future experiments so this finding can be further illuminated. Within this data set, the main disgust propensity effect appeared to have manifested as a result of an opposing pattern between the exposure groups (rather than an effect exclusive to one condition).

It is interesting that although disgust exposure influenced both the RT and rating data (bound similarly with disgust propensity), it did not result in an increased proportion of unpleasant responses to food images. This may simply indicate that causing a binary unpleasant classification to be made (where it wouldn't be otherwise), in response to stimuli that are generally regarded as very pleasant, relies on disrupting a process that is too ingrained to be affected by such exposure. The sensitivity of the rating data may have allowed for this exposure effect to manifest more easily. Alternatively, it is possible that the more affective nature of this disgust manipulation was able to produce classification biases only after participants had sufficient time to assess and evaluate the stimuli. Disgust exposure has been demonstrated to influence higher cognitive elaborative assessments (see chapter 3.3), and it is possible that the rating task in this experiment is further evidence that it is these types of assessments (drawing upon more elaborate cognitive processes) that are predominantly impacted by disgust.

Throughout the experiment, exposure influences were modulated exclusively by disgust propensity rather than sensitivity. Given that disgust propensity may effectively widen the range of stimuli that participants regard as disgusting, this finding may not be so surprising. As disgust propensity is associated with further processing of stimuli, rather than the initial detection and reaction to it (as disgust sensitivity is; Borg et al., 2012), the fact that the rating data effects were driven by disgust propensity may be further evidence for these mood related exposure effects manifesting on a cognitive rather than a perceptual level. This could potentially explain why the priming effects in chapter six were also modulated by disgust sensitivity, whereas the effects in this chapter were driven exclusively by disgust propensity.

Attentional focus was associated with a reduced number of unpleasant classifications in the disgust exposure group. The finding that this effect only manifested in the disgust exposure group suggests that this likely represents an increased ability to prevent the disgusting scenarios in working memory from biasing assessments. Slightly surprising was the finding that attentional focus was associated with a general increase in unpleasant classifications of food images (relative to pleasant ones) regardless of exposure group. It is possible that, in conjunction with the former effect, this may reflect an increased reduction in unpleasant classifications of pleasant stimuli as a result of attentional focus, rather than an increase for food stimuli. However, it is worth noting that both of these attentional focus effects were only borderline significant and would need further investigation before strong conclusions could be drawn.

7.4.2. The influence of disgust exposure on the processing of disgust images.

Disgust exposure appeared to have a strong influence on the classification and assessment of the disgust images. The increase in disgust classifications resulting from disgust exposure was the only stimuli and exposure interaction that was not related to individual differences in disgust propensity. If food images are generally pleasant enough that such exposure could not influence the proportion of classifications within the task, then this result would suggest that stimuli that are more likely to result in unpleasant assessments are the ones that can be influenced by this exposure. Thus, this finding may reflect an increased disgust assignment of the few stimuli within the disgust set that may not have been classed as disgusting as easily as the others. This finding suggests that fast forced choice assessments can be impacted by disgust exposure in a similar way to the responses in priming paradigms. It is worth noting that although this could be interpreted as a congruence effect (between exposure and stimuli), the lack of a fear contrast permits the possibility that this effect was one driven by valence rather than specifically by disgust. However, this still has important implications for the capacity of disgust to colour such rapid assessments of negative stimuli.

Perhaps the most striking finding in this experiment was the strong correlation between disgust propensity and the disgust rating scores for the disgust stimuli, but only for the group that had been exposed to disgust. This does provide evidence for the notion that disgust exposure can increase the level of disgust experienced by subsequently encountered disgusting entities if individuals are sufficiently prone to disgust. The demarcation between the elicitors in the sentences and stimuli ensures that this effect was not one that was driven by familiarity between the elicitors and images. It is possible that disgust propensity serves as a protective influence – ensuring that individuals who encounter disgust can more easily identify future contamination threats. Given that disgust propensity so strongly increased disgust ratings (of disgust stimuli) following such exposure, it is possible that the fact that it also did so for food stimuli (but to a reduced extent) suggests that this influence also has the potential to overextend and contaminate assessments of (some) otherwise pleasant stimuli. The fact that RT was generally slowed (regardless of stimuli) in the disgust group as a result of increasing disgust propensity may suggest that increased perceptual resources are dedicated to processing emotional stimuli (regardless of content) following such exposure.

The additional finding that attentional shifting was associated with a slower RT to disgust images may simply represent an increase in RT for pleasant images (which may be more easily responded to as they present little ambiguity). The contribution of attentional shifting (rather than focus), may represent increased ability to engage with the classification task while also retaining the sentences in working memory. The relative contribution of attentional focus and shifting are explored in more detail in chapters eight and nine (as these paradigms are associated with attentional allocation more generally).

7.4.3. Conclusion.

The results in this chapter confirmed the hypothesis that disgust exposure influenced the processing of food images, but this influence was dependent on levels of disgust propensity. Both RT and disgust ratings of food stimuli were impacted (slowed and increased respectively), a finding that provides evidence for the notion that disgust can negatively influence the assessment of food (by specifically making it appear more disgusting than it would ordinarily), but may only do so amongst individuals who are more susceptible to disgust. Disgust propensity also strongly increased the disgust reported towards disgusting stimuli, but only following disgust exposure. Taken together, these results highlight the importance of disgust propensity in modulating the outcomes associated with disgust, and extend these modulations to both assessments of otherwise pleasant food images and to mood related congruence effects. The following two chapters focus on the electrophysiological responses to emotional stimuli that result from prior disgust exposure, and address the issue of the extent to which perceptual effects emerging from such exposure can influence disgust specifically (rather than negative stimuli in general).

Chapter 8. Are Emotional ERPs Influenced by Exposure to Disgusting Sentences?

8.1. Introduction

Chapter seven suggested there was a link between the processing of food related images and disgust exposure; however, it also reinforced the notion that the processing of subsequently encountered disgusting information can be influenced by prior exposure to disgust (particularly with high levels of disgust propensity). This chapter expounds on this by examining whether prior exposure to disgust also influences emotional ERPs, and whether any such influence is specific to disgust, or manifests less specifically for aversive stimuli in general. So far the work in this thesis has examined the behavioural responses associated with processing emotional images; by examining ERPs that specifically map to emotion processing mechanisms, the influence of disgust exposure can be examined more directly (at least for perceptual mechanisms).

Although there were RT effects in chapter seven, many of the strongest results highlighted the consequence of disgust exposure on more elaborate emotional evaluations. It is conceivable that if these are the primary mechanisms that disgust influences, then emotional modulation of ERPs may not occur – as post-perceptual processes could predominantly be the ones affected by such exposure. However, as emotional priming effects were observed (strongly bound to disgust propensity and sensitivity) in chapter six, and more affective influences on perception (strongly bound to disgust propensity) in chapter seven, it was expected that disgust exposure would influence the early perceptual processes indexed by ERPs. If it were demonstrated that disgust exposure could influence emotional perception, as well as emotional response and elaborative emotional assessment, it would highlight the myriad and diverse ways in which disgust is able to affect emotional experience. When combined with the existing research showing that disgust can disrupt processing and influence evaluations outside the emotional domain (see chapter three), this would emphasise the importance of disgust to many important everyday experiences. Thus, rather than focussing on response data, this experiment focussed exclusively on ERPs using a simple sequential stimuli viewing paradigm.

The experiment presented in this chapter used only disgust, fear and neutral images. Using only three stimuli categories within such a paradigm allows for a large sample of trials to be averaged for each without unduly elongating the experiment and producing potentially diminishing affective responses, or attentional lapses, as the trials progress. Emotional ERP components appear to be most consistently associated with broad emotional enhancement (over neutral), with divergence between specific emotional categories appearing infrequently, and less consistently, in the literature. Because of this, although it was hypothesised that processing influences would emerge specifically for disgust, it remains a possibility that disgust and fear modulate ERPs (in comparison to neutral) equivalently along broad emotional grounds. This selection of stimuli allowed for an examination of these potential broad emotional effects, as well as effects specific to disgust.

Both the EPN and LPP were selected as markers of emotion related processing (see chapter four for the reasoning underpinning this selection). The EPN is considered to represent more automatic attentional capture by emotion, whereas the LPP is considered to be more cognitively influenced. If this interpretation of the EPN is correct, then it may be that the EPN is modulated by the emotional stimuli but not by the disgust exposure. There is some evidence the EPN recorded in response to an image is influenced by the image that came before it in the block (Flaisch, Stockburger, et al., 2008); however, this study only found such influences to emerge as a result of the prior image being of positive valence (a valence category absent in this experiment); it was therefore expected that an emotion related EPN deflection would emerge, but there was less justification to assume that it would be modulated by disgust exposure. However, the EPN has been found to be influenced by individual differences in psychological variables associated with emotional processing such as anxiety (Holmes et al., 2008; Mühlberger et al., 2009; Wieser et al., 2010); as a result, it is possible that variables such as disgust propensity and sensitivity, as well as attentional control, could moderate the attentional capture of emotion indexed by the component.

Based on previous literature, there is a greater justification for predicting that the LPP is the component likely to be modulated following disgust exposure. As the middle portion of the LPP (roughly 600-800 ms post-stimulus onset) likely reflects the point in processing where both perceptual and top-down influences are influential (e.g. Weinberg et al., 2012), this may be the point that is the best marker for disgust's influence on subsequent emotion processing. Prior research I have undertaken has suggested that exposure to disgust is associated with an enhanced LPP exclusively for disgusted facial expressions within this window (Hartigan & Richards, 2016), so there is certainly preliminary evidence for this notion. However, the research in this chapter differs in a number of important ways – Hartigan and Richards (2016) used facial expression stimuli and also used video exposure. Although chapter nine uses a similar video manipulation, the research in this chapter uses the sentence manipulations from chapter seven. To make the results more comparable with those of the previous chapters, and also with most of the literature exploring the emotional modulation of the LPP, scene images were utilised (and represented a different range of emotions). These modifications have the potential to dramatically alter the results. Encouraging participants to remember disgusting (or neutral) scenarios could result in an increased recruitment of cognitive resources – a variable which, given the modulation of the LPP as a result of task instructions, could either modulate the deflection, or require heightened levels of attentional control to effectively engage with the main task.

Thus, this chapter uses a serial emotional presentation paradigm to explore whether emotional ERPs are influenced by prior disgust exposure, and whether any modulation is contingent on individual differences in levels of disgust or attention. Given the slightly inconsistent results in the literature regarding specific emotional modulation of the EPN and LPP, it was difficult to hypothesise a clear direction of effects. However, the literature on the increased top-down influences on the LPP as it progresses made it easier to identify this component as the one most likely to be influenced by prior disgust exposure – particularly when induced through consciously remembered disgusting scenarios.

8.2. Method

Participants were fitted with an EEG skullcap upon entering the laboratory; they then completed the main task, followed by the rating task and the questionnaires.

8.2.1. Participants.

Forty participants (between the ages of 18 and 55) took part in the experiment. The mean age was 28.98 (*SD* = 9.34), 25 were female and 38 were right handed.

8.2.2. Stimuli.

A total of 30 each of disgust, fear and neutral images were used in this experiment. The disgust stimuli included the same subcategories as in chapter seven but with some different exemplars. The fear stimuli included images of snakes, sharks, alligators, aggressive dogs, and guns. The neutral images depicted ordinary household objects. The 48 sentences that were used were identical to those used in chapter seven.

8.2.3. Main task procedure.

Each participant was assigned to either the disgust or neutral exposure group upon arriving for the experiments with half (*n* = 20) assigned to each condition, this assignment only affected the sentences participants were exposed to and all instructions remained identical.

The experiment consisted of four blocks of 90 trials – encompassing a single presentation of each of the images within each block. Prior to the main task, participants also completed a short practice block of twenty trials encompassing five repetitions of four unique (not used in the main blocks) neutral images (presented in a random order). The main purpose of this practice block was to ensure that the setup was successful prior to the recording of the ERPs from the main trials. The timings of the practice trials were identical to those of the main blocks (described below).

Participants initially viewed a fixation cross for 1000 ms, followed by the image for 1000 ms and then a 50 ms blank screen. There was an SOA that varied between 1110 and 1400 ms between each trial. Habituation to stimuli appears to be limited in ERP data (Schupp, Stockburger, et al., 2006); thus, rather than using a novel set of stimuli for each block, this experiment opted to use a sizeable number of exemplars for each emotional category within each block and then to repeat them in subsequent blocks. As finding sufficient numbers of stimuli to match the stimuli criteria outlined in chapter 4.3, proved to be difficult, using a novel set for each block in this experiment likely would have resulted in a reduction in stimuli consistency or quality. Despite novelty effects being less of an issue in paradigms such as this, it has been demonstrated that the number of exemplars within the overall set can have an effect on both the EPN and LPP (Wiens et al., 2011). This study indicated that a 90 image set may be sufficient for the emotion related EPN not to be suppressed, so this number was used in each block. This approach essentially resulted in four identical blocks.

After each trial, there was a 10% chance that participants would be prompted to decide whether the image they had just seen was unpleasant or not (using a "yes" or "no" response attached to a left or right response key that was counterbalanced across participants). This procedure followed the one used by Hartigan and Richards (2016), as this study found that explicit emotional assessment was important in bringing out emotional effects associated with exposure. Additionally, the research in chapter six indicated that explicit emotional appraisal was associated with a different pattern of priming results to a non-emotional appraisal task on the same stimuli. This response data was not actually analysed, with the inclusion of this question only to ensure that participants were consciously engaged with assessing the emotionality in the images. Hartigan and Richards (2016) excluded all trials where a response was actually made (as the timing of the response overlapped with the later portion of the LPP, thus influencing the data on a subset of trials); however, due to the timings in this experiment – with the response itself only being prompted after the post-stimulus window for the trial had completely closed – no trials were excluded.

The disgust induction followed the exact procedure (and counterbalances) outlined in chapter seven. Thus, three sentences were presented to remember before each block, and each block was followed by the same recall procedure. As with chapter seven, the recall results were extremely high (with 98% correct classification across participants in both conditions).

8.2.4. Rating task procedure.

The rating task was identical to that of chapter seven (for both stimuli and sentences), but used only the stimuli from the main task of this experiment. The DPSS-R and the ACS were completed after this rating task.

8.2.5. EEG recording.

EEG data were sampled with a digitization rate of 500 Hz using a synamp amplifier (Neuroscan) and a 100 Hz low-pass filter (with a 50 Hz notch filter enabled). Data was DC-recorded using a linked-earlobe as a reference channel. Signals were recorded from 26 electrodes (FP1, FP2, F7, F3, Fz, F4, F8, FC5, FC1, FCz, FC2, FC6, O2,C3, Cz, C4, O1, CP5, CP1, CP2, CP6, P7, P3, Pz, P4 and P8 according to the international 10-20 system). Horizontal eye movements (HEOG) were measured from two electrodes placed at the outer canthi of the eyes. Impedances on all electrodes were kept below 5 kΩ. EEG data were epoched using a pre-stimulus baseline of 100 ms and a window that continued until 1000 ms after stimulus onset. Data were filtered offline using a bandpass filter of .01-40 Hz (after artefact removal).

8.2.6. Artefact correction.

This experiment used an Independent Component Analysis (ICA) approach to correct for major muscle artefacts. This approach was guided primarily by the EEGLAB tutorial (https://sccn.ucsd.edu/wiki/EEGLAB#The_EEGLAB_Tutorial_Outline), but also informed by advice from other sources. This approach was used as some participants had a high number of eye movement artefacts in the data, and more standard trial (or participant) exclusion approaches would have resulted in an unnecessarily reduced sample size.

Firstly, anomalous portions of data were excluded manually for each participant. These portions contained clear visually identifiable noise that was patently not from either common artefacts (such as eye blinks or lateral eye movements) or brain components. After this, the ICA algorithm (using the *extended runica* EEGLAB function) was run on data that was segmented into epochs conforming to those used in the analysis (100 ms before the stimuli until 1000 ms after the stimuli).

This first ICA run was used to identify trials with anomalous data that could be deleted prior to the second (and main) ICA. This was carried out using a semi-automated strategy where potentially anomalous epochs were flagged – based on deviations (in the components themselves) from the other epochs that crossed certain statistical thresholds – and then manually examined. The statistics for automatically flagging epochs were based on detecting substantial divergences based on standard deviation, linear drifts, kurtosis and abnormal spectra (see Delorme, Makeig, Jung, & Sejnowski, 2001). Flagged epochs were examined manually, and those containing component deviations that were not simply higher amplitude deflections concordant with the standard pattern of that component across other trials (but that had exceeded one or more of the statistical thresholds for that trial and thus been flagged) were deleted from the data. As a result, epochs from components that appeared to represent common artefacts (such as eye blinks) were rarely deleted – as these tended to be flagged exclusively on the basis of high standard deviation values alone (rather than as a result of being anomalous relative to the local distribution of component activity). Flagged epochs were more likely to be manually deleted when they were identified as anomalous according to multiple statistical thresholds (with flags based on a single threshold often retained), and when they were temporally close to other deleted epochs. The waveforms for each component were also visually inspected across all epochs and (in a few infrequent cases) clear anomalous deviations (not detected through the statistical thresholding) were manually deleted based on visual inspection alone. The most commonly rejected epochs were those with components indicative of a linear drift (resulting in the deletion of multiple consecutive epochs until the drift returns to baseline); however, trials were also rejected as a result of highly anomalous (and proximally contained) muscle activity (usually representing a participant moving or twitching over a small number of clustered epochs). The average number of trials excluded was 28 (representing close to 8% of the data).

Following the epoch rejection procedure, a second ICA was conducted on the pruned data. This cleaner second decomposition was used to identify the components that would be corrected in the data. Only the first 28 components were examined (though components that were subtracted tended to be in early positions in the decomposition array) and were excluded manually. All but one participant had a maximum of three components subtracted from the data (the one remaining participant had four subtracted), but most participants had two components subtracted. These corrected components almost exclusively conformed to eye blinks and lateral eye movements; though some participants also had vertical eye movements, or clearly identifiable heartbeat artefacts subtracted. Components were only corrected when they clearly corresponded to the pattern of activity associated with these major EEG artefacts. All analyses were conducted on the corrected data.

8.3. Results

8.3.1. EEG data analysis.

A mean amplitude measure was used to identify all ERP components – averaged across regional clusters of electrodes throughout specific post-stimulus onset periods. The time periods and clusters were decided a priori, primarily on the basis of previous literature, (Hartigan & Richards, 2016; Richards, Holmes, Pell, & Bethell, 2013; Weinberg et al., 2013). However, the EPN was partially identified by observing the negative deflection (across the average waveform – collapsed across stimuli and condition) after the second peak. A common method for identifying the EPN is to examine the point at which emotional ERPs diverge (negatively) from neutral; however, due to problems with obtaining a reliable EPN (see chapter 8.3.6), this method could not be used. The EPN was measured over occipito-parietal electrodes (P7, P8, O1 and O2) from 200-280 ms after stimulus. The LPP was measured from centro-parietal electrodes (P3, Pz, P4, Cz, CP1 and CP2) over a long duration (400-1000 ms post-stimulus onset) which was subdivided into early (400-600 ms), middle (600-800 ms) and late (800-1000 ms) windows. These windows were analysed separately as the processes that correspond to the LPP change substantially across this window.

The primary analysis was an emotion (disgust vs. neutral) x exposure group (disgust vs. neutral) mixed ANOVA, which was followed by separate analyses with each of the four individual differences measured entered individually as a continuous variable. Along with the comparison between disgust and neutral stimuli, an identical analysis was also conducted that contrasted fear and neutral. Analyses were conducted individually for the EPN and each of the three LPP windows.

Average scores for the EPN and LPP components for each condition are reported in Table 8 (and see Figure 5 for grand average ERPs).

Table 8. Means (and *SD*) for EPN and centro-parietal LPPs for each set of stimuli in each condition at each time window.

Condition	EPN (200-280)	LPP (400-600)	LPP (600-800)	LPP (800-1000)
Disgust exposure group				
Disgust	9.54 (6.18)	5.97 (4.15)	5.76 (2.98)	3.78 (1.90)
Fear	8.00 (5.80)	5.53 (3.40)	5.20 (2.91)	3.64 (2.74)
Neutral	8.51 (5.35)	1.46 (2.95)	1.44 (3.07)	.55 (2.29)
Neutral exposure group				
Disgust	8.70 (3.25)	7.50 (6.34)	6.72 (5.40)	3.82 (3.66)
Fear	7.28 (3.61)	7.51 (5.44)	5.97 (4.93)	3.59 (3.08)
Neutral	7.80 (3.01)	2.65 (4.72)	1.29 (2.46)	.13 (1.91)

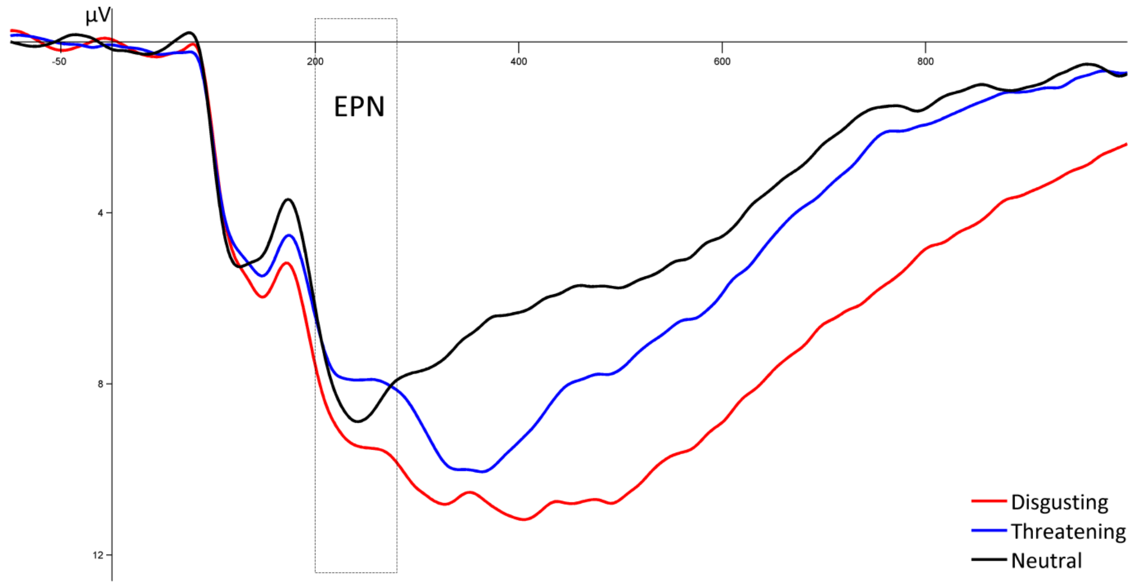

Figure 5. EPN and occipital LPP (Electrodes P7, P8, 01 and 02) for disgusting, threatening and neutral images collapsed across conditions.

8.3.2. EPN (200-280 ms).

8.3.2.1. Disgust and neutral.

There was no significant difference between disgust and neutral EPNs or any interaction with group (all *F*s < .99, all *p*s > .33).

8.3.2.2. Fear and neutral.

There were also no significant differences, nor interaction, in this window between fear and neutral (*F*s < .25, all *p*s > .62).

8.3.3. Centro-parietal LPP (400-600 ms).

Figure 6 shows the grand average ERPs for the LPP (and see also Figure 7 for emotion related topographic maps).

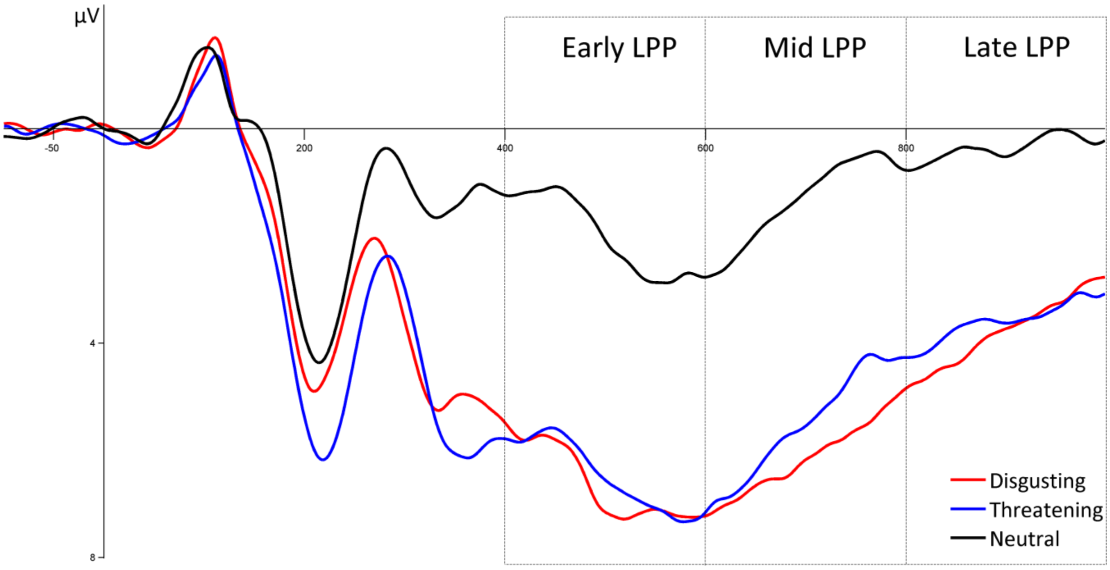

Figure 6. Centro-parietal LPP (electrodes P3, Pz, P4, Cz, CP1 and CP2) for disgusting, threatening and neutral images collapsed across conditions.

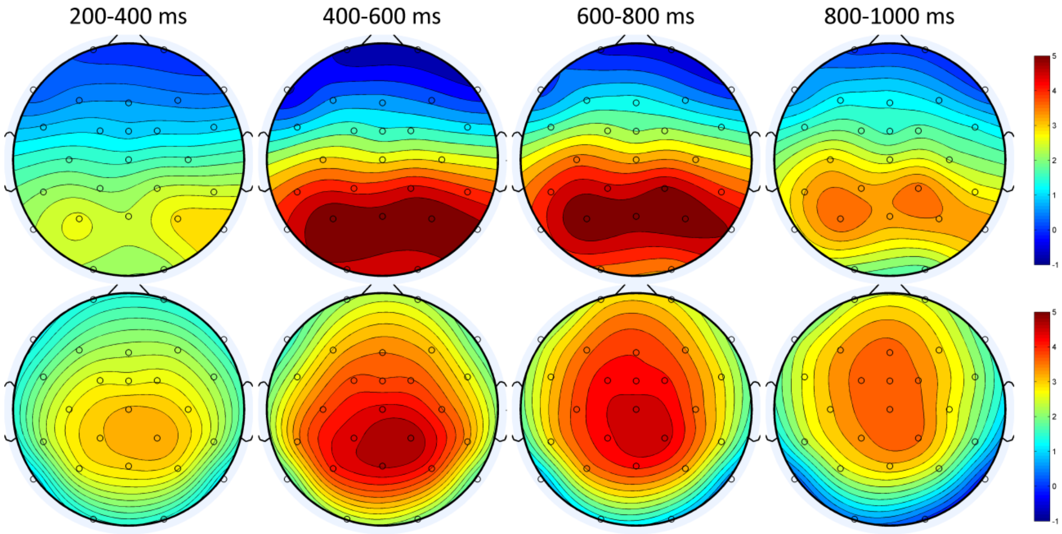

Figure 7. Topographic maps showing the mean amplitude (in µV) enhancement for disgust (top) and fear (bottom) over neutral at each time window (collapsed across condition).

8.3.3.1. Disgust and neutral.

There was a main effect of emotion, with disgust enhanced over neutral ($F(1, 38) = 14.52$, $p < .001$) but there was no group effect or interaction (*F*s < .91, all *p*s > .35). There were no effects related to disgust propensity (all *F*s < 0.86, all *p*s > .36), sensitivity (all *F*s < 1.70, all *p*s > .20) or attentional focus (all *F*s < 1.70, all *p*s > .20). However, there was a significant emotion x condition x attentional shifting interaction ($F(1, 38) = 7.09$, $p = .011$) with a relatively increased LPP for disgusting stimuli in the disgust condition with increasing shifting ability. To examine this in more detail, a difference index was created by subtracting the mean amplitude for neutral trials from the mean amplitude for disgust trials and this was correlated with attentional shifting in both conditions. This analysis revealed a significant negative correlation in the neutral exposure condition ($r(18) = -.49$, $p = .028$; Figure 8) but no significant correlation in the disgust exposure condition ($p = .20$).

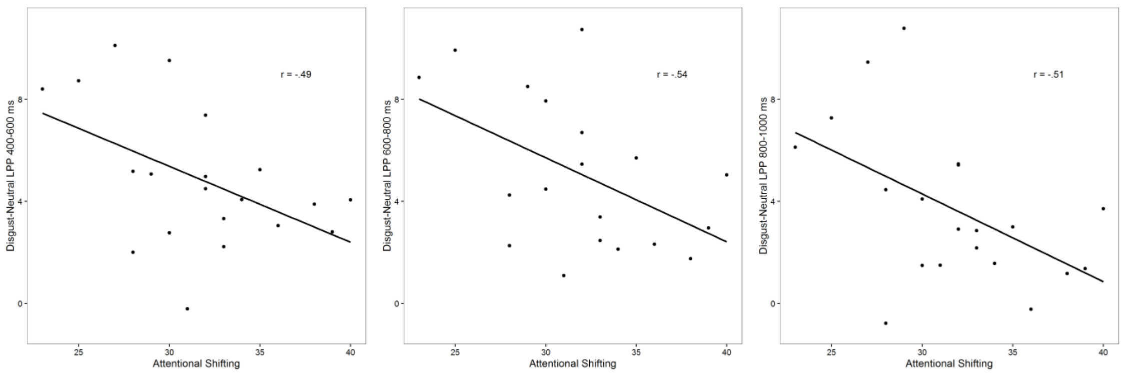

Figure 8. Correlations between the disgust-neutral LPP index and attentional shifting for the neutral exposure group for all three time windows.

8.3.3.2. Fear and neutral.

There was a main effect of emotion with an amplitude enhancement for fear over neutral ($F(1, 38) = 38.76$, $p < .001$) but no group effect or interaction (*F*s < 1.92, all *p*s > .17). There were no effects related to disgust propensity (all *F*s < 0.71, all *p*s > .41), sensitivity (all *F*s < 2.13, all *p*s > .15), or attentional focus (all *F*s < 2.77, all *p*s > .10). There was a significant emotion x condition x attentional shifting interaction ($F(1, 38) = 4.82$, $p = .035$) in the same direction as the disgust result. This was reflected by a similar correlation with the derived difference score (fear minus neutral) within the neutral exposure group that was in the same direction but was not significant ($r(18) = -.40$, $p = .078$) and no correlation in the disgust exposure group ($p = .36$).

8.3.4. Centro-parietal LPP (600-800 ms).

8.3.4.1. Disgust and neutral.

As with the previous window, disgust had an enhanced LPP relative to neutral ($F(1, 38) = 21.31$, $p < .001$) but there was no group effect or interaction (*F*s < 1.51, all *p*s > .23). There were no effects related to disgust propensity (all *F*s < 1.47, all *p*s > .23), sensitivity (all *F*s < .87, all *p*s > .36) or attentional focus (all *F*s < 3.10, all *p*s > .09). However, there was an emotion x condition x attentional shifting interaction that was more pronounced than the previous window (*F*(1, 38) = 8.21, *p* = .007). As before, this effect was driven by a correlation with the disgust minus neutral difference index in the neutral exposure condition (*r*(18) = -.54, *p* = .014) but not the disgust exposure condition (*p* = .44). In order to represent this interaction effect graphically, the participants were sorted into low and high attentional shifting by way of a median split; Figure 9 displays the augmentation of the disgust minus neutral LPP index by prior exposure and attentional shifting group.

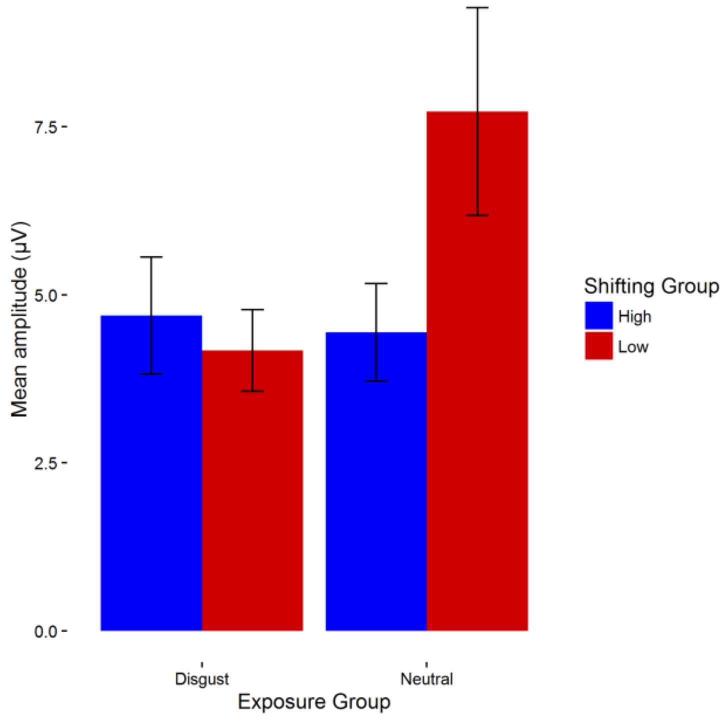

Figure 9. Disgust minus neutral centro-parietal LPP (600-800 ms) for disgust and neutral exposure groups by high and low levels of attentional shifting (bars represent the standard error of the mean).

8.3.4.2. Fear and neutral.

The fear LPP was enhanced over neutral LPP (*F*(1, 38) = 17.94, *p* < .001) but there was no group effect or interaction (*F*s < 1.19, all *p*s > .28). There was an emotion x condition x disgust propensity interaction (*F*(1, 38) = 4.62, *p* = .038) with relatively reduced LPP for fear stimuli in the disgust group with increasing levels of propensity. Further analysis revealed that this effect was driven by a negative correlation between the fear minus neutral LPP index and disgust propensity in the disgust exposure group (*r*(18) = -.68, *p* = .001; see Figure 10) that was not present in the neutral exposure group (p = .75). With the exception of one participant, this difference index did not result in negative scores, thus suggesting that the fear LPP remained generally enhanced over neutral regardless of individual differences in disgust – a finding indicative of a reduced gap between fear and neutral LPP with increasing disgust propensity. A significant positive correlation with disgust propensity and neutral LPP ($r(18) = .47$, $p = .035$) but not fear LPP ($p = .92$) in the disgust exposure group is a further indication of this. There were no significant disgust sensitivity (Fs < 1.19, all ps > .28) or attentional focus effects (Fs < .66, all ps > .42). There were also no significant attentional shifting effects, and although the second-order interactions and main shifting effect appeared to be borderline non-significant (Fs < 3.91, all ps > .056), there was no significant higher-order three-way interaction as there was in the previous window ($F = 2.22$, $p = .14$) indicating no exposure related effects.

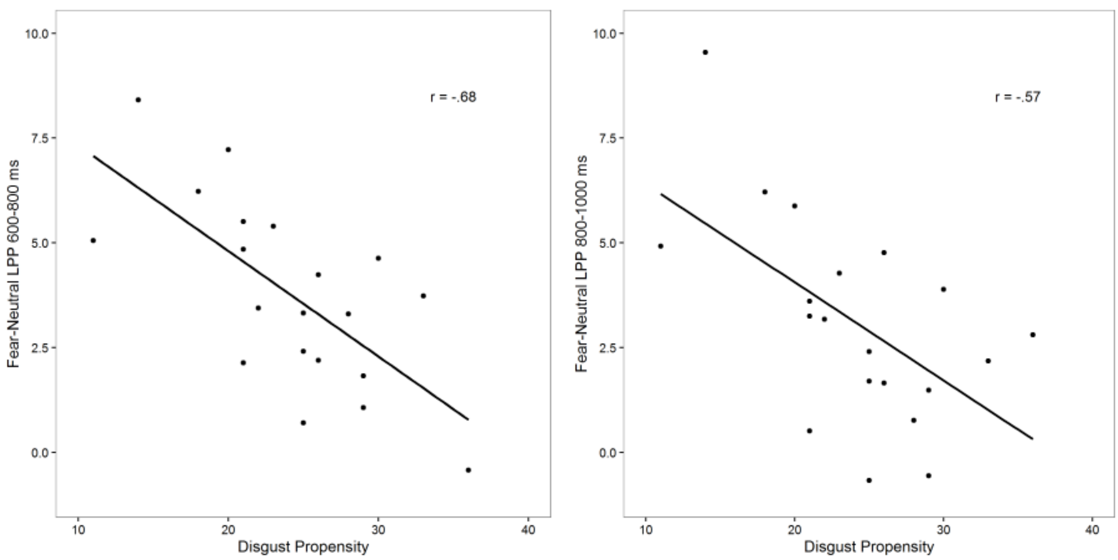

Figure 10. Correlations between the fear-neutral LPP index and disgust propensity for the disgust exposure group for the later two time windows.

8.3.5. Centro-parietal LPP (800-1000 ms).

8.3.5.1. Disgust and neutral.

In this final window, the enhanced LPP for disgust neutral remained significant ($F(1, 38) = 11.62$, $p = .002$), but there was no group effect or interaction (Fs < .07, all ps > .79). There were no effects related to disgust propensity (all Fs < 1.27, all ps > .27), sensitivity (Fs < .19, all ps > .67), or attentional focus (Fs < 2.1, all ps > .16). The significant emotion x condition x attentional shifting interaction from previous windows persisted in the same direction ($F(1, 38) = 7.81$, $p = .008$). As with the previous windows, this was driven by a significant correlation with the disgust change index in the neutral exposure group ($r(18) = -.51$, $p = .022$) but not the disgust exposure group ($p = .44$).

8.3.5.2. Fear and neutral.

The LPP for fear also remained enhanced over neutral in this final window ($F(1, 38) = 8.46$, $p = .006$) but an exposure effect or interaction remained absent (*F*s < .20, all *p*s > .66). Similar to the previous window, there was an emotion x condition x disgust propensity interaction ($F(1, 38) = 5.22$, $p = .028$) that was driven by a negative correlation between the fear change index and disgust propensity in the disgust exposure group ($r(18) = -.57$, $p = .008$) but not in the neutral exposure group ($p = .50$). There were no effects related to disgust sensitivity (*F*s < .76, all *p*s > .39), attentional focus (*F*s < 1.49, all *p*s > .23) or attentional shifting (*F*s < 3.22, all *p*s > .08), with the higher-order three-way interaction that was present in the earliest window not significant here ($F = 2.64$, $p = .11$).

8.3.6. Post hoc analysis of the occipital shifted LPP.

The data in this experiment revealed no emotion related negative deflection in the time period usually indicative of the EPN – although fear was visibly more negative in this window, this was for a very narrow time interval, and disgust was actually more positive than neutral. This finding is discussed in more detail in the discussion (chapter 8.4). However, as can be observed in Figure 5, there was a visibly enhanced positivity for both disgust and fear over neutral that overlapped with the EPN window, and persisted throughout the entire window. This emotion related positive deflection across occipital electrodes is consistent with the component that has been referred to as the *occipital LPP* (or *parietal-occipital LPP*) in some studies (Bublatzky & Schupp, 2012; Foti et al., 2009; Pastor et al., 2007). As existing research distinguishes between the maximally central and maximally occipital LPPs, it is possible that this component influenced the results in this experiment (particularly due to the temporal overlap with the EPN).

As a result, the occipital LPP was analyzed post hoc using the same emotion x exposure group mixed ANOVA (with participants as a random effect). The same four LPP windows were used in the analysis, but the earlier period of 200-400 ms post-stimulus onset (the period overlapping with the EPN) was also examined. As Figure 5 displays a visible enhancement for disgust over fear (in addition to both emotion categories being enhanced over neutral), whether this enhancement was reflected by a significant increase was also examined. Thus, for four time periods (encompassing the 200-1000 ms period), this analysis was performed on all three stimuli contrasts (disgust vs. neutral, fear vs. neutral, and disgust vs. fear). Means for this component are reported in Table 9.

Table 9. Means (and *SD*) for occipital LPPs for each set of stimuli set in each condition at each time window.

Condition	Occipital LPP (200-400)	Occipital LPP (400-600)	Occipital LPP (600-800)	Occipital LPP (800-1000)
Disgust exposure group				
Disgust	10.35 (5.47)	10.14 (4.01)	6.60 (2.98)	3.49 (2.71)
Fear	8.81 (5.02)	7.14 (3.72)	3.39 (2.62)	1.19 (2.22)
Neutral	7.82 (4.34)	5.30 (3.14)	2.59 (2.65)	.96 (2.02)
Neutral exposure group				
Disgust	9.70 (2.82)	10.50 (3.91)	7.00 (3.17)	3.69 (2.51)
Fear	8.65 (3.07)	7.87 (3.03)	3.76 (2.45)	1.19 (2.05)
Neutral	7.20 (2.52)	5.83 (2.48)	2.62 (1.89)	.93 (1.67)

8.3.6.1. Occipital LPP (200-400 ms).

For the disgust and neutral contrast, there was an enhanced occipital LPP for disgust over neutral ($F(1, 38) = 9.99$, $p = .003$) but no exposure or interaction effect (*F*s < .27, all *p*s > .61). For the fear and neutral contrast, there was an enhanced occipital LPP for fear stimuli ($F(1, 38) = 5.99$, $p = .019$) but no exposure or interaction effect (*F*s < .87, all *p*s > .36). For the disgust and fear comparison, there were no significant effects (all *F*s < 1.11, all *p*s > .30).

8.3.6.2. Occipital LPP (400-600 ms).

For the disgust and neutral contrast, there was an enhancement for disgust over neutral (F(1, 38) = 24.75, p < .001), but no exposure or interaction effect (Fs < .18, all ps > .67). For the fear and neutral contrast, there was an enhanced occipital LPP for fear (F(1, 38) = 6.61, p = .014), but no exposure or interaction effect (Fs < .44, all ps > .51). The comparison between disgust and fear revealed a significant enhancement for disgust in this window (F(1, 38) = 5.78, p = .021) but no exposure or interaction effect (Fs < .38, all ps > .54).

8.3.6.3. Occipital LPP (600-800 ms).

There was still an increased occipital positivity for disgust over neutral in this window (F(1, 38) = 18.01, p < .001), but no exposure or interaction effect (Fs < .95, all ps > .33). Fear was no longer enhanced over neutral in this window, and there was no exposure effect or interaction (Fs < 2.30, all ps > .14). Disgust remained enhanced over fear (F(1, 38) = 9.14, p = .004) with no exposure or interaction effects (Fs < .70, all ps > .41).

8.3.6.4. Occipital LPP (800-1000 ms).

Disgust remained enhanced over neutral in this window (F(1, 38) = 10.44, p = .003) but with no exposure or interaction effects (Fs < .22, all ps > .64). There were no significant effects for the fear and neutral contrast (Fs < 2.40, all ps > .63). Disgust remained enhanced over fear in this window (F(1, 38) = 4.94, p = .032) but there was no exposure or interaction effect (Fs < .13, all ps > .72).

8.3.7. Post hoc analysis of rating data.

Table 10 displays the rating data for both exposure groups. Disgust propensity appeared to modulate the fear and neutral comparison (for the 600-1000 ms period) but only in the disgust exposure group. As chapter seven revealed that disgust propensity tended to influence responses only among individuals who had been exposed to disgust, and in light of this LPP finding, correlations between the disgust rating data and the three stimuli categories were examined in both groups. Disgust propensity was significantly positively correlated with disgust ratings for disgusting (r(18) = .58, p = .007) and threatening (r(18) = .46, p = .042), but not neutral (p = .36) stimuli in the disgust exposure group, but there were no significant correlations in the neutral exposure group (all ps > .25). In contrast, disgust sensitivity did not correlate with disgust ratings for any stimuli category in either exposure group (ps > .14). Thus, the pattern of results for the ratings data would appear to be concordant with those of chapter seven.

Table 10. Mean (*SD*) for disgust, threat and pleasant ratings for all three stimuli categories.

	Disgust	Fear	Neutral
Disgust exposure group			
Disgusting rating	5.91 (.99)	2.52 (1.72)	1.11 (.14)
Threatening rating	2.96 (1.94)	5.28 (1.29)	1.19 (.27)
Pleasant rating	1.26 (.35)	2.44 (1.30)	3.70 (2.06)
Neutral exposure group			
Disgusting rating	6.08 (.64)	2.34 (1.39)	1.10 (.15)
Threatening rating	2.71 (1.51)	5.45 (1.32)	1.23 (.33)
Pleasant rating	1.45 (.61)	2.51 (1.51)	4.85 (1.34)

8.4. Discussion

This experiment revealed a general LPP enhancement for disgusting and threatening (over neutral) stimuli consistent with the most common emotion related LPP findings in the literature. A novel finding was that disgust propensity reduced the emotion related increase in the LPP for fear over neutral but only among those exposed to disgust. The main finding was that attentional shifting effectively suppressed the LPP for both disgusting and threatening stimuli, but only did so among individuals who were *not* exposed to disgust. This effect persisted longer into the LPP window for disgust than fear. A post hoc analysis revealed an increased occipital LPP for disgust over both threatening and neutral stimuli from 400-1000 ms (and an enhancement over neutral from 200 ms post-stimulus onset). As with chapter seven, disgust propensity correlated with increased disgust ratings for disgust images (and also for fear images in this experiment), but only amongst individuals who were exposed to disgust. There were no effects associated with the EPN. The novel results will be discussed in turn.

8.4.1. Disgust propensity influences on the LPP and disgust ratings of stimuli.

The main analysis revealed a relatively reduced LPP for fear (compared to neutral) as a function of increasing disgust sensitivity (in the disgust exposure group only). However, follow up analysis suggested that this effect may actually have resulted from disgust propensity increasing the LPP for neutral (thereby increasing the baseline comparison stimuli category). This effect manifested in the latter two LPP windows – intervals which are theorised to be associated with increasing top-down influences (see chapter 4.2.8). Although the LPP is modulated by numerous task related, and stimulus driven, variables, it has been speculated that it may broadly reflect a shifting of attentional resources (Ferrari et al., 2008). Given that this disgust propensity effect only emerged in the disgust exposure group (and only for periods consistent with increasing top-down influences), it is possible that this effect may signify an increased emotional alertness with increasing disgust propensity. Under this interpretation, exposure to disgusting sentences results in a generally increased emotional reactivity as disgust propensity increases – thus increasing the LPP for even neutral stimuli. Given that fear stimuli augment the LPP (regardless of propensity or exposure), the lack of enhancement of fear stimuli could simply be indicative of a ceiling effect for these stimuli – whereas neutral stimuli typically do not enhance the LPP, so the LPP in response to these images can be augmented.

Although it is possible to interpret this finding as an increased stimulus driven affective response to neutral stimuli (such that these images are actually perceived as more unpleasant, or emotionally evocative, following disgust exposure amongst individuals with high disgust propensity), there are a number of things that make this interpretation unlikely. Firstly, the earlier LPP window is the one most influenced by the properties of the stimuli, and the effect only emerged in the more cognitively sensitive later windows. Secondly, this was not reflected in the rating data – where disgust propensity increased the disgust ratings of disgust and fear stimuli, but not of neutral stimuli. Finally, the former interpretation is more consistent with the notion discussed in previous chapters (see chapter seven) that disgust propensity may result in a hypervigilance towards potential disgust elicitors after an initial disgust experience.

As with chapter seven, the results here pointed to an effect specifically for disgust propensity (rather than sensitivity). As disgust sensitivity represents the visceral unpleasantness associated with experiencing disgust, if (as was found here) effects are not tied to specifically disgust provoking images, then the inability for disgust sensitivity to exert an influence may be consistent with the psychological construct represented by this scale of the DPSS-R. In this experiment (and in chapter seven), disgust propensity was associated with an increasing modulation of perceptual and evaluative experience following disgust exposure – as both the LPP, and the assessment of disgust for both sets of unpleasant stimuli (disgust and fear), were influenced by disgust propensity. It is interesting that as well as affecting evaluative processes following disgust exposure, disgust propensity can also affect emotional perception (both measured in RT and emotional ERPs). Disgust propensity thus appears to be strongly associated with altering both rapid and more elaborative processes after disgust exposure, and the results here provide evidence for disgust propensity increasing electrophysiological emotional reactivity.

8.4.2. Attentional shifting influences on the LPP.

Higher levels of attentional shifting appeared to suppress the LPP for negative stimuli in general (both disgust and fear) for the 400-600 ms window, but only for participants who had not been exposed to the disgusting sentences. Although the memory task had low difficulty, the ability to remember these sentences while simultaneously completing the main task (and engaging with the emotional classification of the stimuli) could still have been affected by individual differences in ability to shift attention. Given that attentional shifting only exerted an influence on individuals who were not exposed to disgusting sentences, this would seem to indicate that the influence of attentional shifting was effectively washed out with disgust exposure. In the neutral exposure group, attentional shifting suppressed the LPP for unpleasant stimuli, whereas it had no noticeable influence in the disgust exposure group. This could indicate that although attentional shifting can suppress emotional reactivity (as defined by the emotional augmentation of the LPP), an increased state of disgust can override high shifting participants' ability to moderate affective responses in this way.

Although there are no studies (that I am aware of) that have examined the LPP magnitude as a function of individual differences in attentional control, there is evidence that reducing attentional resources can have a suppressive effect on the LPP (MacNamara, Ferri, et al., 2011) and it is possible that the act of remembering highly evocative disgust scenarios effectively consumes more cognitive resources than remembering neutral sentences – thus enabling attentional shifting differences to emerge only for the latter. If the ability to shift attention, rather than to focus it, influenced the LPP here because of the nature of this disgust manipulation (requiring working memory ability), then the lack of comparable effects (relating to attentional shifting) associated with the same manipulation in chapter seven is curious. It could be that the increased number of unpleasant stimuli in this experiment (including both a disgust and fear category) influenced this, or it could simply be that (unlike RT measures) the direct indexing of the neural allocation of attention represented by the LPP is sensitive enough to detect these attentional effects. Chapter nine addresses some of these issues by exploring whether attentional shifting still exerts an influence when the disgust manipulation is not associated with task instructions (using a task-free affective mood manipulation).

In the earliest LPP window, attentional shifting modulated the ERPs for both disgusting and threatening stimuli. However, in the later two windows, this effect was only present (to a significant degree) for the disgust and neutral comparison. This may be a result of the increased unpleasantness (or decreased pleasantness) associated with the disgust images (see Table 10). If attentional shifting ability could suppress the emotional responses to these images, it is possible to speculate that given the tendency for disgust to aversively affect processing for a more sustained period than fear (see chapter three), that these images continued to exert an influence later in the processing stream (i.e. across the two later windows of the LPP) such that individual differences in attention continued to be required to moderate them. Chapter nine continues to explore the attentional modulation of disgust and fear images. However, if it is the case that the LPP is moderated by attention for a longer period for disgust than fear stimuli, it is further evidence for the ways in which these different aversive stimuli are processed – requiring divergent levels of attentional control and manifesting with a different time-course.

8.4.3. Occipital LPP and EPN findings.

Although the EPN is regarded as a component that represents automatic attentional capture by emotional stimuli (see chapter 4.2.6), the failure to find such emotional modulation within this time window is not unprecedented. For example, although Pastor et al. (2007) found an enhanced EPN for pleasant stimuli, there was no EPN modulation for unpleasant images (in fact, neutral was more negative as with this experiment). It is possible that the EPN is (at least to some extent) dependent on the range of emotional categories present within the stimuli set. Another possible explanation is dependent (to some extent) on the paradigm used. However, this latter interpretation seems unlikely as Hartigan and Richards (2016) used a very similar paradigm (that also induced disgust) and found emotional EPN enhancement for disgusted, angry and happy facial expressions. Chapter 10 discusses stimuli inconsistencies between ERP studies, which could potentially account for some of these discrepant ERP results for core emotional components. Chapter nine may also elucidate this finding as it uses the same set of stimuli and also examines the EPN.

However, the substantial positive drift that was observed across these occipito-parietal electrodes began in the window typically associated with the EPN. It is difficult to reconcile the existence of a positive drifting occipital-centred LPP with a negative drifting occipital centred EPN. These could, like the centro-parietal LPP, represent distinct overlapping processes within the same time window, but in a standard analysis of ERP data, these components should theoretically diminish each other. PCA analysis is a good method of identifying the components that overlap within ERP data, and the analysis by Foti et al. (2009) found distinct parietal and occipital positivities *and* negativities that were emotionally sensitive. Given the temporal loading peaks of these PCA components, the positivity in this experiment was seemingly closest to the 353 ms peaking "parietal positivity" identified by Foti et al., though it is possible that it also indexed the 841 ms peaking "occipital positivity". As these two components were only functionally distinguished by a pleasant vs. unpleasant comparison in the data of Foti et al. (with only the occipital positivity being sensitive to such a contrast), and given the lack of pleasant category within the present experiment, it may not be possible to compare the results here (and doing so may be beyond the scope of the questions addressed by this thesis).

The component typically referred to as the *occipital LPP* tends to be studied in the context of development – where the research suggests that the more centrally maximal LPP observed in adults is occipitally maximal in children and shifts over time (Hajcak & Dennis, 2009; Kujawa, Klein, & Proudfit, 2013). In adult participants, Bublatzky and Schupp (2012) found that the parietal-occipital LPP was a component sensitive to threat (specifically, in that experiment, threat of electric shock) as well as the emotional properties of visual stimuli. However, given the vastly different paradigms, it is difficult to compare the results of Bublatzky and Schupp (2012) with those of the present experiment. The present experiment seemed to indicate that this parietal-occipital LPP was sensitive to disgust over fear stimuli – thus exhibiting a degree of emotion specificity not typically present in ERP data.

Given that the LPP is regarded as a marker of attentional resource allocation, any associated LPP differences between disgust and fear are unlikely to result from semantic activation of emotional categories – that is to say that discrepant emotions, that modulate attention equally, should not diverge based on current theory. If this occipital LPP is enhanced for disgusting stimuli, it would likely reflect the increased attentional allocation associated with disgust (over fear). As can be observed in Figure 5, the fear waveform dissipated sooner than the disgust waveform; given that both emotions were enhanced over neutral for this component in the earlier LPP window, the pattern of increased augmentation of disgust over fear, coupled with the insignificant differences between fear and neutral after 600 ms, may be indicative of a greater tendency for disgust to recruit top-down attentional or cognitive resources for further processing (as these processes are typically what the latter LPP windows reflect). This would, to some extent, cohere with the existing literature on the ways in which disgust and fear are processed – with fear provoking an immediate affective response that is rapidly processed and disengaged from, whereas disgust influences processing for a longer period but with a less immediate affective spike (see chapter three). However, given that there does not seem to currently be a clear theory delineating the functions of the centro-parietal LPP and the occipital LPP (among adult participants), it is difficult to speculate as to what this discrepancy between disgust and fear may reflect. It is also important to note that these results were explored post hoc and were not part of the intended analysis. However, the experiment in chapter nine will explicitly explore this occipital LPP component a priori. If a similar disgust related positivity is present in that study, it would lend credence to the occipital LPP finding in this chapter.

8.4.4. Conclusion.

The results in this chapter indicated that prior exposure to disgust influenced emotional ERPs, but did so in conjunction with disgust propensity and attentional shifting. Disgust propensity appeared to increase the LPP baseline among individuals who were exposed to disgust, whereas attentional shifting suppressed the emotional deflection of the LPP – but this effect was washed out by disgust exposure. Attentional control exerted an influence on processing of disgust images for longer into the processing stream than for fear images. There was no clear EPN, but there was an enhanced occipito-parietal LPP that appeared to be augmented for disgust independently of exposure. All of these findings are elucidated further in chapter nine, which describes a very similar experiment, but using a different disgust induction method.

Chapter 9. Are Emotional ERPs Influenced by Exposure to Disgusting Videos?

9.1. Introduction

The results of chapter eight appeared to establish that the emotion related deflection in the LPP was affected by prior exposure to disgusting sentences, but that this effect was related to both disgust propensity and attentional shifting. However, these findings prompt another series of questions. If attentional shifting was able to suppress the LPP (an effect apparently washed out through the manipulation), was this because the nature of the task required working memory and the ability to engage with the emotion task whilst also remembering the sentences? Further, if remembering disgusting sentences resulted in disgust propensity augmenting the baseline LPP, is this contingent on this particular type of manipulation? Both of these questions are addressed in this chapter by utilising an identical ERP paradigm to chapter eight, but varying only the type of manipulation. The experiment presented in this chapter utilises a video manipulation, with no memory requirement, that should serve as an affective mood manipulation. If attentional shifting only exerted an influence in chapter eight as a result of what was effectively a dual task operating over the experiment, then it would not be expected to do so when such a task-free mood manipulation is utilised instead. Likewise, both the results in chapter seven and eight found behavioural and ERP effects that were related to disgust propensity, but both of these experiments used the sentence manipulation. It may be expected that disgust propensity increases disgust assessments (or emotional assessment in general) following exposure to disgust in a variety of forms, but there could be something specific to the conscious rumination on disgusting events (present in the sentence manipulation, but not the one in this chapter) that is particularly effective for individuals high in disgust propensity.

The other main finding from chapter eight, that requires further investigation, involves the ERP data from the parietal-occipital electrodes. Against expectation, there was no clear emotional deflection for the EPN, but there was a sustained positivity that began within the EPN window and continued until 1000 ms. This positivity was enhanced for disgust over both fear and neutral stimuli. Given that this finding was analysed post hoc, it may not be best to interpret too much from this experiment alone. However, this chapter aims to explicitly examine the occipital LPP and to examine whether the disgust enhancement found in chapter eight was an anomaly.

Previous research has found that the type of video manipulations used in this chapter can influence the later parts of the LPP when facial expressions are used as the stimuli (Hartigan & Richards, 2016). Although facial expressions embody the same emotional categories as the emotion scene stimuli used in this thesis, there are substantial structural differences between the stimuli types; in addition, for EEG research, faces are associated with the emergence of entire processing components (such as the N170) that are not present for scenes – thus indicating substantial processing differences. Given the processes that the EPN and LPP map to, it is possible to speculate that although additional components emerge as a result of processing faces, these emotion related components should not be evoked equivalently. However, there is evidence that both the EPN and LPP in response to facial expressions, in contrast to scene images, are not significantly modulated by emotion at all (Thom et al., 2014). It is worth noting that this paper used anger stimuli within the scene image set – depicting events such as Nazi rallies, which could require increased top-down processing to interpret and affectively process due to their visual ambiguity. Facial expressions and scenes depicting easily discernible objects may be identifiable sooner in processing, and thus evoke emotion related ERPs sooner. The finding that emotional faces do not evoke an enhanced EPN and LPP is somewhat inconsistent with findings from other studies (e.g. Hartigan & Richards, 2016; Schupp, Öhman, et al., 2004), though Thom et al. (2014) address this by speculating that presenting faces in conjunction with scenes may have led to the pattern of results they found. Regardless of whether this explanation is accurate, there do seem to be some inconsistencies with the extent to which faces can reliably produce an emotion related LPP (or EPN). Given that the results in Hartigan and Richards (2016) indicated that the LPP in response to specifically disgusted facial expressions was influenced by prior disgust exposure, the present experiment (which uses very similar disgust elicitors but exclusively uses scene images) should illuminate the extent to which such effects were facial-stimuli dependent.

Videos have been a very common and effective method of inducing disgust in participants. The strong aversive sensation such manipulations have on participants has been a common method used to examine the very physiology associated with disgust (see chapter 3.4.1). The results of Viar-Paxton and Olatunji (2012) indicated that when only examining the short-term effects of disgust induction, it may be more effective to present disgust elicitors in multiple contexts. This study, like Hartigan and Richards (2016), used multiple distinct disgust videos – presented to participants between blocks in the experiment. This approach ensures that the feelings of disgust are renewed by participants in between blocks. In contrast to chapter eight, no recall or memory task was required of participants. The videos thus served as a mood manipulation, and ERP related effects can be solely attributable to this emotional element, rather than to attentional related influences.

In sum, the experiment presented here examined the same range of ERP outcomes as chapter eight, using an identical stimuli selection, but varied the nature of the disgust manipulation – using emotionally intense videos instead. The contribution of disgust propensity and sensitivity, along with attentional focus and shifting, continue to be examined in the analysis. Similar exposure related modulation of the LPP was expected to that found in chapter eight, with the influence of attentional shifting potentially expected to play a reduced role (assuming that it only modulated ERPs due to the nature of the task in chapter eight).

9.2. Method

As with the previous experiment, participants were fitted with an EEG skullcap upon entering the laboratory; they then completed the main task, followed by the rating task and the questionnaires.

9.2.1. Participants.

Thirty-six participants (between the ages of 18 and 55) took part in the experiment, but two were excluded due to excessive noise in the EEG recording. An additional participant was excluded due to participation in the (recent) previous experiment (and thus familiarity with the stimuli sets). Of the remaining 33 participants, the mean age was 27.97 (SD = 9.72), 13 were female and 31 were right handed.

9.2.2. Stimuli.

A total of 30 each of disgust, fear and neutral images were used in this experiment. These were identical to the stimuli used in chapter eight. Eight videos (four each of disgusting and neutral videos) were adapted from YouTube uploads (in a manner similar to Hartigan & Richards, 2016), edited to remove sound and cut to 60 seconds in length. The four disgust videos represented a surgical procedure on a rodent, two videos depicted maggots being removed from human feet, and the final video depicted botflies being removed from a monkey. None of these disgust elicitors overlapped with those in the image stimuli (following the logic of the sentence manipulations in chapter seven and eight). The neutral videos were matched to contain similar aesthetic elements to the disgust videos; thus, two included home recordings of small animal pets (a rabbit and a gerbil – neither of which were depicted in the image set);

the other two videos included human feet, but depicted orthopaedic sports massage. None of the videos (in either condition) included depictions of human faces.

9.2.3. Main task procedure.

Each participant was assigned to either the disgust or neutral exposure conditions upon arriving; after exclusions, this resulted in 17 participants in the neutral group, and 16 in the disgust group.

The experiment consisted of four blocks of 90 trials, with a 20 trial practice block, that were identical (in stimuli and presentation timings) to those in chapter eight. As with chapter eight, participants were asked for an assessment of whether or not the image was unpleasant in 10% of the trials. Before each block, participants were instructed to view one of the four videos for their exposure condition (randomly selected without replacement – so that participants saw each of the four videos once over the course of the experiment). After participants watched a video, they were immediately asked to decide how unpleasant (on a scale of 1-7) the video was. The label "unpleasant" was used for this assessment (rather than "disgusting") so as to avoid verbally priming participants towards processing the disgust images differently. The disgust videos were rated at 5.94 (*SD* = .73), and the neutral videos at 2.06 (*SD* = 1.11) using this measure. In addition, after the experiment was concluded, participants were asked to decide how disgusting they found watching the four videos they viewed to be overall (on the same 7-point scale); the disgust videos were rated at 6.06 (*SD* = .77), and the neutral videos were rated at 1.94 (*SD* = 1.78) using this measure.

9.2.4. Rating task procedure.

The rating task was identical to that of chapter eight, but only included the images. Both the DPSS-R and the ACS were completed after the rating task.

9.2.5. EEG recording.

The recording setup was identical to the setup used in chapter eight.

9.2.6. Artefact correction.

This experiment used the same ICA approach as chapter eight, using the same guidelines for identifying and deleting anomalous trials, and for removing major artefact components. The average number of trials excluded (prior to the second ICA run) for this data set was 33 (representing approximate 9% of the data); the number of corrected components for each participant varied between one and four, but the average number of components corrected for was two.

9.3. Results

Table 11 provides a breakdown for the rating data (as with previous experiments) for both exposure groups.

Table 11. Mean (SD) for disgust, threat and pleasant ratings for all three stimuli categories.

	Disgust	Fear	Neutral
Disgust exposure group			
Disgusting rating	5.45 (.85)	2.78 (1.64)	1.55 (.80)
Threatening rating	2.52 (1.36)	5.73 (.82)	1.66 (.94)
Pleasant rating	1.68 (.88)	2.43 (1.19)	4.61 (1.48)
Neutral exposure group			
Disgusting rating	5.99 (.88)	2.49 (1.26)	1.27 (.79)
Threatening rating	2.46 (1.69)	5.64 (1.38)	1.43 (1.07)
Pleasant rating	1.18 (.28)	2.10 (1.28)	4.09 (1.53)

9.3.1. EEG data analysis.

The same time windows and electrodes as chapter eight were used to identify the components for analysis. The only exception was for the EPN, which (based on the waveform collapsed across stimuli and condition) was shifted slightly later than the previous experiment. Thus, the EPN was examined at a time window encompassing 210-290 ms post-stimulus onset. The three centro-parietal LPP windows from chapter eight (400-600, 600-800 and 800-1000 ms) were examined, as was the parietal-occipital LPP from 200-1000 ms (broken into 200 ms windows and using the four electrodes used for the EPN). As with chapter eight, the occipital LPP was analysed only for main experimental effects (i.e. without the inclusion of trait measures).

The analyses mirrored that of chapter eight, with the exposure group factor (disgust vs. neutral) representing the videos participants were exposed to. Average scores for the EPN and LPP are reported in Table 12.

Table 12. Means (and *SD*) for EPN and centro-parietal LPPs for each set of stimuli in each condition at each time window.

Condition	EPN (210-290)	LPP (400-600)	LPP (600-800)	LPP (800-1000)
Disgust exposure group				
Disgust	9.25 (3.37)	7.04 (3.43)	6.39 (2.75)	4.38 (2.49)
Fear	8.63 (3.45)	7.02 (2.79)	5.99 (2.59)	4.56 (2.70)
Neutral	9.17 (2.73)	3.32 (1.91)	2.05 (1.73)	1.26 (2.03)
Neutral exposure group				
Disgust	11.04 (7.15)	6.36 (4.48)	5.47 (4.04)	3.21 (3.54)
Fear	8.82 (6.75)	6.50 (4.09)	4.65 (3.49)	3.18 (2.94)
Neutral	10.07 (6.09)	2.33 (3.23)	.97 (2.31)	.22 (2.14)

9.3.2. EPN (210-290 ms).

As with chapter eight, there was no clear EPN for disgust, but there was an increased negativity for fear in this time window (see Figure 11).

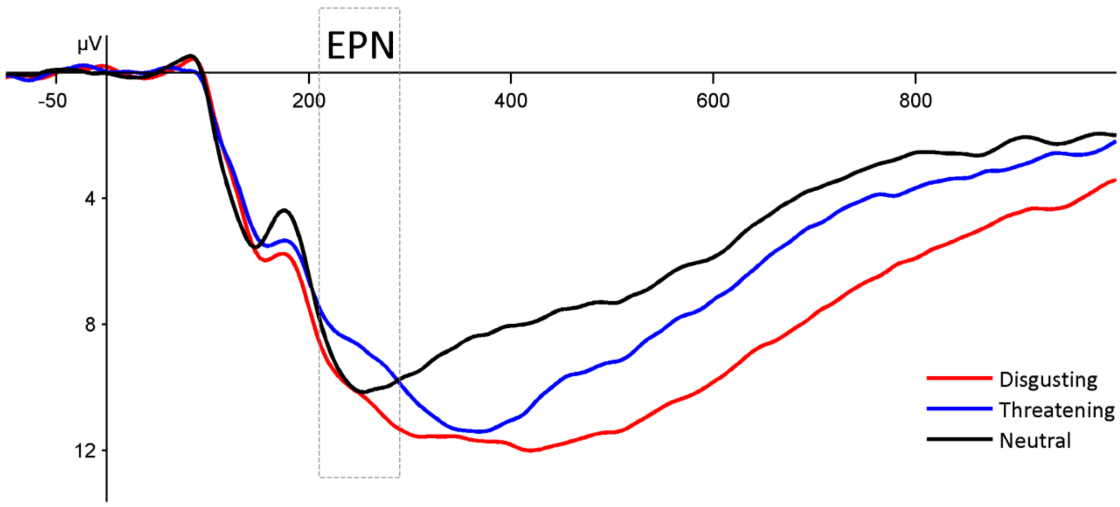

Figure 11. EPN and occipital LPP (Electrodes P7, P8, 01 and 02) for disgusting, threatening and neutral images collapsed across conditions.

9.3.2.1. Disgust and neutral.

There was a significant emotional effect, with a *decreased* EPN for disgust compared to neutral (i.e. higher absolute amplitude for disgust; $F(1, 31) = 4.42$, $p = .044$). This counterintuitive finding may be partially attributable to the overlapping occipital LPP results (see chapter 9.3.6). There were no effects related to disgust propensity (all *F*s < 1.31, all *p*s > .26), disgust sensitivity (all *F*s < 2.80, all *p*s > .10), attentional focus (all *F*s < 1.74, all *p*s > .20) or attentional shifting (all *F*s < 1.79, all *p*s > .19).

9.3.2.2. Fear and neutral.

There were no significant effects for this comparison (*F*s < 2.83, all *p*s > .10). Thus, the apparent increased negativity for fear stimuli was not significant.

9.3.3. Centro-parietal LPP (400-600 ms).

Figure 12 shows the grand average ERPs for the LPP (and see Figure 13 for emotion-related topographic maps).

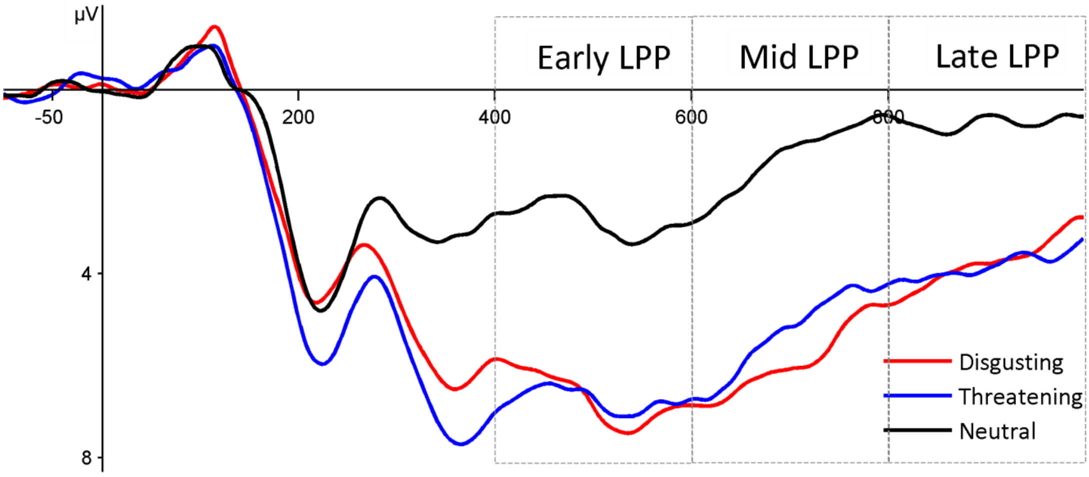

Figure 12. Centro-parietal LPP (electrodes P3, Pz, P4, Cz, CP1 and CP2) for disgusting, threatening and neutral images collapsed across conditions.

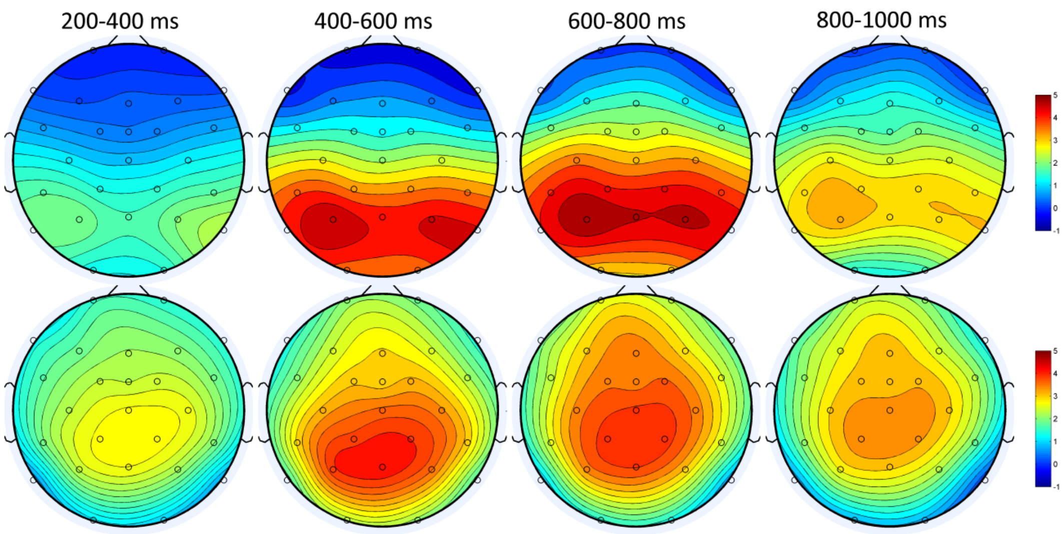

Figure 13. Topographic maps showing the mean amplitude (in µV) enhancement for disgust (top) and fear (bottom) over neutral at each time window (collapsed across condition).

9.3.3.1. Disgust and neutral.

There was a main effect of emotion with disgust enhanced over neutral ($F(1, 31) = 10.84$, $p = .002$) but no group effect or interaction (Fs < .57, all ps > .46). There were no effects related to disgust propensity (all Fs < 2.30, all ps > .14) or disgust sensitivity (all Fs < 2.73, all ps > .11). There was a significant interaction between emotion, exposure group and attentional focus ($F(1, 31) = 6.29$, $p = .018$) with *increased* LPP for disgust following disgust exposure with increasing levels of attentional control. There were no effects related to attentional shifting (all

Fs < 1.78, all ps > .19). As with the LPP results in chapter eight, to examine this in more detail, a difference index was created by subtracting the mean amplitude for neutral from the mean amplitude for disgust. This index was a significantly positively correlated with attentional focus in the disgust exposure condition ($r(14) = .65$, $p = .006$; Figure 14) but not in the neutral exposure condition ($p = .70$). Following the procedure in chapter eight, in order to represent this effect graphically, a median split was performed to derive a low and high attentional focus group; Figure 15 shows the enhancement of the disgust minus neutral LPP index for both exposure groups by attentional focus.

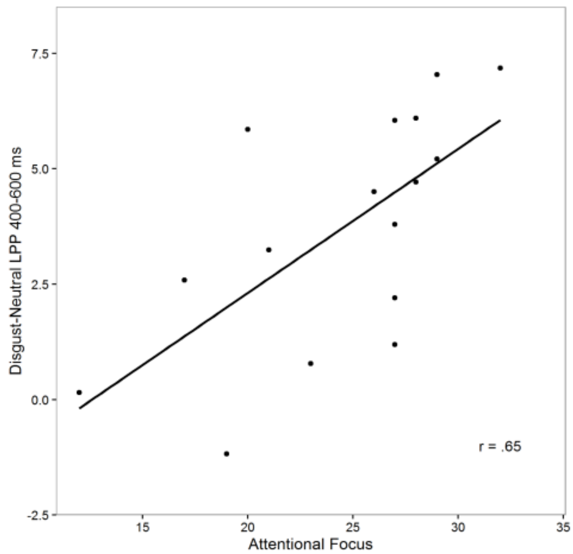

Figure 14. Correlation between the disgust-neutral LPP index and attentional focus for the disgust exposure group for the 400-600 time window.

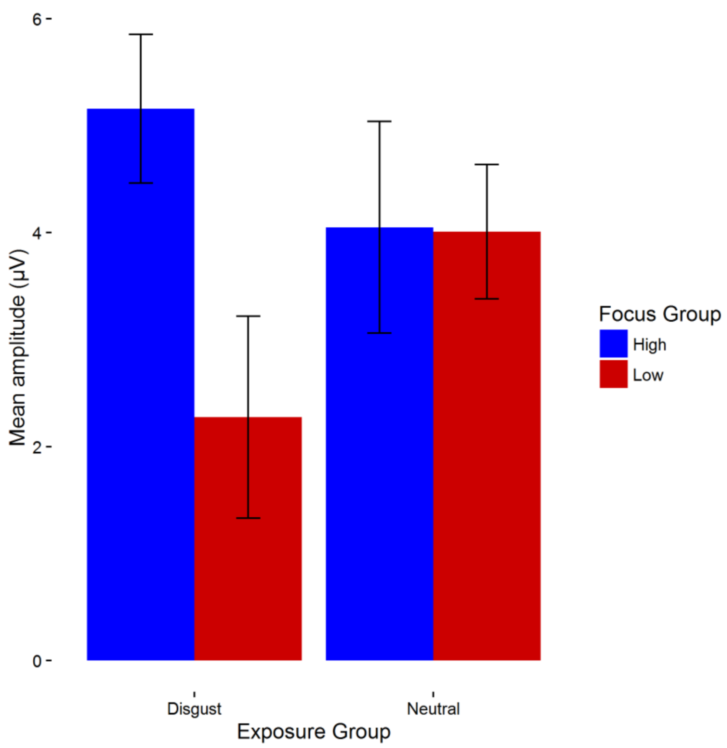

Figure 15. Disgust minus neutral centro-parietal LPP (400-600 ms) for disgust and neutral exposure groups by high and low levels of attentional focus (bars represent the standard error of the mean).

9.3.3.2. Fear and neutral.

There was a main effect of emotion with fear enhanced over neutral ($F(1, 31) = 19.03$, $p < .001$) but no group effect or interaction (*F*s < .94, all *p*s > .34). There were no effects related to disgust propensity (all *F*s < .53, all *p*s > .47), disgust sensitivity (all *F*s < 2.31, all *p*s > .14), attentional focus (all *F*s < 1.46, all *p*s > .24) or attentional shifting (all *F*s < .30, all *p*s > .59).

9.3.4. Centro-parietal LPP (600-800 ms).

9.3.4.1. Disgust and neutral.

There was a main effect of emotion with disgust enhanced over neutral ($F(1, 31) = 9.75$, $p = .004$) but no group effect or interaction (*F*s < 1.32, all *p*s > .26). There were no effects related to disgust propensity (all *F*s < .89, all *p*s > .35) or disgust sensitivity (all *F*s < 1.71, all *p*s > .20). The higher-order interaction between emotion, exposure group and attentional focus (that was significant in the previous window) was in the same direction, but was not significant in this window ($F = 3.98$, $p = .055$), and there were no other significant effects. There were no effects related to attentional shifting (all *F*s < 1.07, all *p*s > .31). Although the interaction with attentional focus was not significant in this window, attentional focus continued to correlate positively (though to a diminished degree) with the disgust increase over neutral index in the disgust exposure group ($r(14) = -.51$, $p = .043$) but not in the neutral exposure group ($p = .55$).

9.3.4.2. Fear and neutral.

There was a main effect of emotion with fear enhanced over neutral ($F(1, 31) = 7.94$, $p = .008$) but no group effect or interaction (*F*s < 1.18, all *p*s > .24). There were no effects related to disgust propensity (all *F*s < 1.62, all *p*s > .21), disgust sensitivity (all *F*s < 1.42, all *p*s > .24), attentional focus (all *F*s < .46, all *p*s > .50) or attentional shifting (all *F*s < 1.45, all *p*s > .24).

9.3.5. Centro-parietal LPP (800-1000 ms).

9.3.5.1. Disgust and neutral.

There was a main effect of emotion with disgust enhanced over neutral ($F(1, 31) = 4.42$, $p = .044$) but no group effect or interaction (*F*s < 1.89, all *p*s > .18). There were no effects related to disgust propensity (all *F*s < .40, all *p*s > .53), disgust sensitivity (all *F*s < 1.35, all *p*s > .25), attentional focus (all *F*s < 2.31, all *p*s > .14) or attentional shifting (all *F*s < 1.07, all *p*s > .31).

9.3.5.2. Fear and neutral.

There was a main effect of emotion with fear enhanced over neutral ($F(1, 31) = 5.78$, $p = .022$) but no group effect or interaction (*F*s < 2.35, all *p*s > .14). There were no effects related to disgust propensity (all *F*s < .22, all *p*s > .64), disgust sensitivity (all *F*s < .77, all *p*s > .39), attentional focus (all *F*s < .35, all *p*s > .56) or attentional shifting (all *F*s < 1.39, all *p*s > .25).

9.3.6. Parietal-occipital LPP (200-400 ms).

Figure 11 displays the ERPs for all three exposure types across the entire 200-1000 ms window (using the same electrodes as the EPN) and Table 13 provides the means for this component across the analysis window.

Table 13. Means (and *SD*) for occipital LPPs for each set of stimuli set in each condition at each time window.

Condition	Occipital LPP (200-400)	Occipital LPP (400-600)	Occipital LPP (600-800)	Occipital LPP (800 - 1000)
Disgust exposure group				
Disgust	9.78 (3.56)	10.70 (3.94)	7.97 (3.21)	5.25 (2.70)
Fear	9.48 (3.60)	8.99 (3.32)	5.95 (3.01)	3.87 (2.61)
Neutral	8.56 (2.82)	6.97 (2.55)	4.33 (2.39)	2.85 (2.56)
Neutral exposure group				
Disgust	11.85 (6.32)	11.69 (4.98)	7.48 (4.60)	4.05 (3.94)
Fear	10.29 (5.91)	9.16 (4.73)	4.26 (4.23)	2.11 (3.62)
Neutral	9.49 (5.34)	7.22 (4.15)	3.49 (3.38)	1.78 (3.24)

For the disgust and neutral comparison, there was a main effect of emotion with disgust enhanced over neutral ($F(1, 31) = 11.98$, $p = .002$) but no group effect or interaction (*F*s < 3.10, all *p*s > .09). There were no significant effects in the fear and neutral comparison (all *F*s < .40, all *p*s > .53). For the disgust and fear contrast, there was an interaction between emotion and exposure group ($F(1, 31) = 5.95$, $p = .021$) with reduced LPP for disgust (relative to fear) in the disgust exposure group. Figure 16 illustrates this effect and indicates that there was a decrease in the occipital LPP for both disgust and fear in the disgust exposure group, but that this decrease was steeper for disgust. It is worth noting that, despite this interaction, disgust was still enhanced over fear as a main effect ($F(1, 31) = 12.21$, $p = .001$).

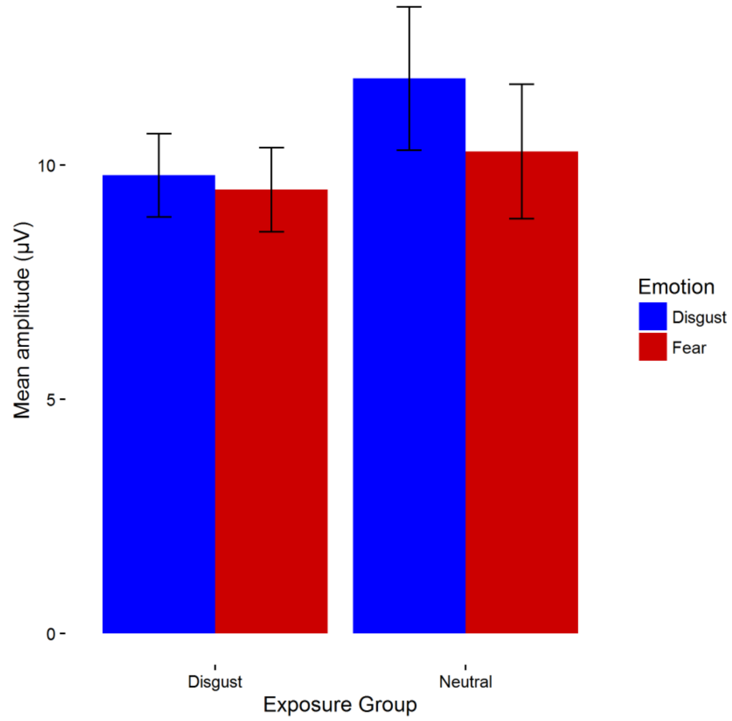

Figure 16. Occipital LPP (200-400 ms) for disgust and fear images in disgust and neutral exposure groups (bars represent 95% confidence interval).

9.3.7. Parietal-occipital LPP (400-600 ms).

For the disgust and neutral comparison, there was a main effect of emotion, with disgust enhanced over neutral (F(1, 31) = 24.18, p < .001) but no group effect or interaction (Fs < 1.17, all ps > .29). There were no significant effects for the fear and neutral comparison (all Fs < 2.82, all ps > .10). For the disgust and fear comparison, there was an increased LPP for disgust (F(1, 31) = 13.82, p < .001), but no group effect or interaction (Fs < 2.02, all ps > .17).

9.3.8. Parietal-occipital LPP (600-800 ms).

For the disgust and neutral comparison, the enhancement for disgust remained (F(1, 31) = 12.51, p = .001) but no group effect or interaction (Fs < .33, all ps > .57). There were no significant effects for the fear and neutral comparison (all Fs < 1.41, all ps > .24). For the disgust and fear comparison, there was an increased LPP for disgust (F(1, 31) = 16.81, p < .001), but no group effect or interaction (Fs < 3.03, all ps > .09).

9.3.9. Parietal-occipital LPP (800-1000 ms).

In the final window, the main emotional enhancement for disgust over neutral was borderline non-significant, and there were no other significant effects (*F*s < 3.83, all *p*s > .059). There were no effects for the fear and neutral comparison (all *F*s < 1.45, all *p*s > .24). For the disgust and fear comparison, disgust continued to be enhanced over fear ($F(1, 31) = 6.55$, $p = .016$) but there was no group effect or interaction (*F*s < 1.80, all *p*s > .19).

9.4. Discussion

The typical LPP enhancement for emotional over neutral stimuli was present across the entire LPP. Further, for the comparison between disgust and neutral, this discrepancy was enhanced with increasing levels of attentional control, but only for individuals who were exposed to disgusting videos. The occipital LPP increase for disgust over both neutral and fear in chapter eight was replicated here.

9.4.1. Attentional control moderates the influence of disgust priming.

The increase in LPP for disgusting over neutral stimuli was enhanced by prior disgust exposure, and this gap increased linearly with increasing levels of attentional focus. This result was not present for the fear and neutral contrast. This finding is somewhat counterintuitive given that previous research has found attentional control to be a factor that overrides disgust manipulations (van Dillen et al., 2012). However, given the specific nature of the task in this experiment, there are some possible interpretations that do not conflict with such previous findings. Hartigan and Richards (2016) found that emotional engagement (through assessing the emotion of the stimuli) was a necessary prerequisite to bring out the effects of disgust propensity on the LPP and by focusing on a non-emotional aspect (the gender of the facial model), these exposure effects did not emerge. As with the results here, the experiment found an increased LPP specifically for disgusting stimuli following disgust exposure using a paradigm that encouraged participants to affectively engage with the stimuli (by assessing its unpleasantness). It is possible to speculate that under such conditions, attentional focus may actually facilitate the engagement with the emotional assessment task (with such increased engagement enhancing the exposure influences). In line with this, it is worth noting that the final study of van Dillen et al. (2012) found that increasing emotional engagement eliminated the attention related disgust suppression effects found in the other studies. The results here may indicate that in addition to preventing exposure effects, encouraging participants high in attentional focus to engage with the emotional stimuli of the task may actually result in disgust exposure effects emerging.

The other studies in van Dillen et al. (2012) found that a non-emotional cognitive task was influenced by disgust exposure, but that attentional control could override these effects by facilitating disengagement from the disgusting material. However, in order to fully engage with the task in this experiment, participants were explicitly required to assess the stimuli on an affective level. If emotional engagement with relevant stimuli, following such a manipulation, increases the LPP (as Hartigan & Richards, 2016, found) then engaging more closely with the task here may have increased the effectiveness of the disgust manipulation. Thus, it is possible that the results here point to a task-directed increase in emotional engagement with the stimuli for individuals high in attentional focus that resulted in increased disgust exposure effects. As there was no task requirement to remember the disgust exposure videos (as there was with the sentences in chapter eight) this could explain the different LPP effects between the two experiments. Chapter 10 discusses these differences in more detail.

The results of chapter eight did not produce effects similar to those of Hartigan and Richards (2016); however, using a similar video manipulation, the results here produced the same increased LPP for specifically disgusting stimuli – only in this experiment, the effect emerged with increasing attentional control. This clearly highlights the importance of not just the emotional content of the exposure, but the induction method as well. As the LPP indexes both task related cognitions and affective responses, it is important for future experiments to consider the processes that the different exposure mechanisms bring out when deciding on an appropriate exposure manipulation. As predicted, attentional shifting did not modulate the results here (as it did with the results of chapter eight), and the effect of attentional focus manifested both in a different exposure group (the disgust group) and in a different direction to the attentional shifting effects of chapter eight. It therefore seems likely that these separable attentional mechanisms can influence discrepant methods of disgust induction – with attentional shifting playing an increased role when a dual task is present (as with when participants are required to remember the exposure stimuli while simultaneously assessing the task stimuli). See chapter 10 for an assessment of the range of attentional effects over the body of work presented in this thesis.

The aforementioned attentional focus effect was most prominent in the earliest LPP window (representing 400-600 ms post-stimulus onset), this effect was largely diminished across the 600-800 ms window (to the point that the interaction was borderline non-significant, though the correlation remained significant), and was entirely diminished in the final (800-1000 ms) window. These timings are concordant with the exposure effects in Hartigan and Richards (2016) where it was found that the exposure and stimuli effects interacted most prominently at 450-650 ms post-stimulus, whereas the post 650 ms period was associated with more top down cognitive influences. Given such similarities, the borderline result in the 600-800 ms window in this experiment likely reflects an effect early in the window (which was selected prior to data analysis) that had dissipated before the end. This earlier period of the LPP is one characterised by a relatively increased influence of the emotion of the stimuli (see chapter 4.2.8), and thus the finding that this is the point at which emotional responses to the images are impacted by prior disgust exposure is concordant with prevailing LPP theory. The findings of this experiment partially corroborate those of Hartigan and Richards (2016) and give credence to the notion that affective processing of specific emotional stimuli can be influenced by prior exposure to that stimuli, and that the LPP can reflect such a specific emotional influence.

9.4.2. Occipital LPP and EPN effects.

There was a visibly enhanced EPN deflection for threatening stimuli, but this was not significant. Disgust was actually associated with a significantly decreased LPP (i.e. was more positive in magnitude) compared to neutral. The pattern of the EPN, along with increased positivity in the centro-parietal region that began in this time window, was very similar to that of chapter eight (see Figures 5 and 11). Given the enhanced positivity for disgusting stimuli in the parietal-occipital regions, this EPN result likely reflects this positive deflection for disgust, rather than reflecting an enhanced emotional response for the neutral stimuli. It is curious that both the results of chapters eight and nine failed to find a reliable EPN. As the nature of the disgust manipulation changed between studies, but the emotional images remained the same, it is most reasonable to conclude that the selection of stimuli prohibited an EPN emerging. As was discussed in chapter eight, other studies have similarly failed to find a reliable EPN. Given that the EPN is speculated to reflect automatic attentional capture by emotional stimuli (see chapter 4.2.6), results such as this one may present a challenge to such a general interpretation and suggest that certain other stimuli properties within emotional images may be required for the EPN to emerge. Alternatively, the EPN may be (partially) dependent on the balance of stimuli within the experiment, or the specific paradigm. Chapter 10 discusses stimuli discrepancies between published studies as a potential explanation, but given the ratings data, and the reliable LPP results, across both this experiment and chapter eight (along with the emotional effects in previous behavioural chapters), the failure to find an emotion related EPN is unlikely to be a result of the stimuli failing to produce an emotional response.

The earliest occipital LPP window (200-400 ms) revealed a significantly enhanced deflection for disgusting stimuli over both neutral and fear. For the disgust and fear comparison, this window also appeared to find an interaction between stimuli and exposure group in a direction that indicated an overall decreasing LPP in the disgust exposure group that decreased further for disgust than fear stimuli. However, interpretation of this effect is difficult as fear stimuli had a more negative amplitude than disgust in the overlapping EPN window across the same electrodes (210-290 ms). Although this could represent a reduction of the LPP for disgust following exposure – possibly mirroring the centro-parietal exposure effect (for disgust stimuli) but as a negative-going (rather than positive) effect brought about due to the location of the LPP dipole (in a similar way to the coactivation of the N170 and the Vertex Positive Potential components; Joyce & Rossion, 2005) –, the failure to find this effect in later windows, and the complications due to the overlap with the EPN (which influenced disgust and fear differently), would reduce confidence in any such interpretation. As the centro-parietal LPP window was analysed from 400 ms post-stimulus onset, this may mark a better starting time period to examine a parietal-occipital LPP equivalent. Despite this, as with chapter eight, disgust was augmented over both neutral and fear stimuli (regardless of condition) from as early as 200 ms.

The pattern of enhanced occipital LPP for disgust (over both neutral and fear) remained for each time window – with the exception of the comparison between disgust and neutral in the 800-1000 ms window which was borderline non-significant (though Figure 11 reveals a visible, but diminished, enhancement for disgust relative to the earlier windows). This pattern of results mirrors those of chapter eight and provides further evidence for the notion that this parietal-occipital LPP may represent an enhancement specifically for disgust stimuli (that manifests regardless of condition). This effect appears to be at its most potent from 400-800 ms post-stimulus onset. The LPP is typically modulated at the level of emotion (compared to neutral), or valence, and there is limited existing evidence for an LPP enhancement for one specific emotional category. This disgust-specific enhancement in both chapter eight and nine does seem to provide evidence for divergence in ERPs within the broad emotional category. Given that both disgust and fear stimulate different action tendencies and autonomic responses (see chapter 4.3), and can differentially influence perceptual processing (van Hooff et al., 2013, 2014), it is possible that differential neural processing streams are stimulated by disgust and fear stimuli early enough into processing that they can manifest in LPP data. As the LPP appears to represent the employment of attentional resources, the results here could indicate that, later into perception, disgust requires an increased level of attention to fear to shape the action tendencies and behavioural outputs associated with the emotion. The only caveat to this is that the effect manifests in the parietal-occipital variant of the LPP, which is a component that has been subject to far less investigation than the more common centro-parietal variant. Although prior research appears to confirm that both a central and occipital shifted late positivity are implicated in emotion processing (Bublatzky & Schupp, 2012; Foti et al., 2009), the mechanisms that these distinct components reflect do not appear to be well understood currently. In building such an understanding, the research in this chapter (and chapter eight) provides evidence that this occipital LPP is enhanced for disgust stimuli specifically and could provide evidence of the increased attentional resources required to process the emotion.

9.4.3. Conclusion.

The results of this chapter reinforce and extend those of chapter eight by indicating that disgust exposure can influence the processing of specifically disgusting stimuli. Exposure to disgusting videos increased the LPP in response to disgusting (but not threatening) stimuli but only for individuals high in attentional focus. The discrepancies in the pattern of results between this chapter and chapter eight have implications for the ways in which the method by which disgust is induced can have very different consequences on emotional perception. Overall the results of this chapter were in line with Hartigan and Richards (2016) and indicated that an intense disgust mood manipulation could increase the attentional resources dedicated to processing specifically disgusting stimuli; the results here extend these findings by implicating attentional focus as an important variable in moderating these effects (when the task explicitly involves affective appraisal). As with chapter eight, there was an enhanced occipital LPP for disgust over both fear and neutral stimuli that was most prominent from 400-800 ms post-stimulus onset – this finding could provide evidence for a specific ERP marker of disgust processing. The final chapter in this thesis explores the ways in which the results from the various experiments presented here combine to enhance our understanding of the ways in which disgust exposure influences multiple aspects of emotional perception.

Chapter 10. Conclusions, Implications and Future Directions

10.1. Aims of this Thesis

Relative to other commonly studied basic emotions, disgust is an emotion with an unusual autonomic pattern and set of behavioural tendencies. There has been a great deal of evidence over the last decade indicating that disgust is associated with a range of behavioural and psychological outcomes – most notably morality and political positions. Along with the substantial amount of research that has suggested that exposure to disgust influences moral evaluation, there is a growing body of research that has documented the ways in which such exposure can also influence perceptual processing. Most of the research on this topic explores the extent to which disgust has the capacity to disrupt perceptual and evaluative processes (such as those that are used to engage with other cognitively demanding tasks). This thesis aimed to explore the question of the extent to which disgust exposure influences emotional perception and affective processing. By exploring the dynamics of disgust exposure in the context of a variety of emotional exposure paradigms, a number of processes associated with emotion could be investigated. In the course of investigation, behavioural and electrophysiological measures were utilised, and perceptual and evaluative outcomes were explored. Central to this thesis was also an exploration of whether key individual difference measures (disgust propensity, disgust sensitivity and attentional control) had the potential to modulate such influences (as they have been shown to do with other disgust exposure influences). By exploring disgust's influence on a range of predominantly perceptual processes, using a variety of induction measures, and exploring the ways in which individuals vary in susceptibility to such an influence, this thesis aimed to shed light on the dynamics of disgust processing and the ways it influences the perception of emotional stimuli encountered in the environment.

10.2. Summary of Main Findings

Taken as a whole, this thesis supports the notion that disgust is able to influence a variety of aspects of emotional perception, but does so in conjunction with particular levels of trait disgust or attentional control. Further, the influence of these trait variables varies depending on the nature of the mechanism recruited by the cognitive task, and the nature of the disgust induction method. Many of the observed effects showed a high degree of emotional specificity – with studies finding an influence of disgust exposure on the processing of specifically disgusting images. The findings reported in each chapter have more detailed implications for the specific areas investigated, but overall the results do seem to suggest that exposure to disgust is able to exert a strong and specific influence on the ways we process emotional information, but that individuals differ considerably in the extent to which such an influence can manifest.

The only experiment which failed to reveal disgust exposure effects was in chapter five. Chapter six revealed that higher levels of disgust propensity and sensitivity increased the congruence processing benefit gained from processing a disgust prime followed by a disgust target. These effects only manifested when the primes were supraliminally presented (i.e. were on screen for long enough to be fully discernible) and when participants were explicitly attempting to identify disgusting stimuli. There was also evidence of disgusting prime and target combinations slowing response times when the targets were evaluated for non-emotional features (the number of colours). Pivotally, there were no effects when fear primes and targets were congruent. These results highlight the ways in which trait disgust enhances the detection of specifically disgusting information in the environment following disgust exposure. With regard to emotion theory more generally, these results suggest that congruent priming influences can emerge for one specific emotion as a result of encouraging participants to focus on detecting that specific emotion.

The research in chapter seven revealed that exposure to disgusting written scenarios differently influenced the ways in which pleasant images of food were evaluated – an effect also dependent on levels of disgust propensity. This manifested as a slower classification of the food images among higher disgust participants (relative to the classification speed of high disgust participants in the neutral exposure group). This exposure also resulted in more negative assessments of food images – with participants rating them as more disgusting (in conjunction with individual differences in levels of disgust propensity) following disgust exposure. This provides evidence that disgust is able to affect the perception and assessment of food images, but does so predominantly for those who have an elevated propensity to find events and experiences disgusting. In addition, this experiment also demonstrated that both reaction time and explicit disgust assessments of disgusting images were impacted by disgust exposure – an effect that increased with levels of disgust propensity. Overall these results provide evidence that assessments of both disgusting and otherwise pleasant food stimuli are impacted similarly by prior disgust exposure for individuals with higher levels of disgust propensity.

Both chapter eight and nine revealed a sustained occipital positivity for disgusting stimuli over both fear and neutral stimuli, regardless of exposure. This would seem to be preliminary evidence for a novel ERP marker of disgust processing, and it is possible (given what is known about such sustained occipital positivity), although speculative, that it reflects the increased attentional resources required to process disgusting stimuli. With regards to disgust exposure, chapter eight revealed that attentional shifting was able to suppress the modulation of the LPP for both disgust and fear, but that this emotional suppression effect was washed out by exposure to written scenarios that were actively remembered. This experiment also suggested that disgust propensity increased the baseline emotional LPP response following disgust exposure. Chapter nine used a more affective task-free exposure manipulation (through intensely disgusting videos), and found that increased levels of attentional focus led to an increase in LPP for disgust stimuli specifically. These results are in line with earlier work using a similar manipulation (Hartigan & Richards, 2016), and suggest that disgust mood manipulations have the ability to alter the perception of specifically disgusting stimuli depending on engagement with the stimuli.

10.3. Theoretical Implications

10.3.1. The influence of trait disgust in moderating the effects of disgust exposure.

Many of the findings in this thesis were contingent on individual differences in levels of disgust propensity and sensitivity. There was a great deal of cohesion between experiments in the direction of these effects – with higher levels of trait disgust consistently amplifying the consequences associated with disgust exposure. Many of these effects have important implications for the consequences of disgust exposure and contribute to our understanding of the mechanisms that are impacted by them. As well as identifying which mechanisms are impacted, the nature of these results can shed light on the dynamics of these processing mechanisms and contribute more generally to our understanding of how emotional information is processed, and how individual differences can play a hugely consequential role in this processing. This section details the ways trait disgust (both in the form of disgust propensity and sensitivity) was revealed to impact the processing of specifically disgusting stimuli, as well as the processing of non-aversive stimuli, with a focus on how the similarities and differences in results between the experiments in this thesis enhance our understanding of these issues. This section also details the ways in which attentional control was found to moderate the effects of disgust exposure across the different paradigms.

10.3.1.1. Trait disgust's role in processing disgusting images following exposure.

Given what is known about the ways in which emotional exposure primes individuals towards processing subsequent stimuli of the same emotional category (see chapter three), it was anticipated that exposure to disgust would result in a noticeable influence on disgust processing specifically. Whether or not this influence would be highly contingent on individuals having higher levels of trait disgust was less clear based on the existing literature. The experiments in this thesis demonstrated that disgust exposure appears to have very different influences on the processing of subsequent disgusting stimuli depending on individual differences in trait disgust. Many of the reported effects in this thesis appeared not to emerge at all for individuals low in disgust propensity or sensitivity – for example, see Figure 3 for a demonstration of how the data points representative of individuals low in disgust are close to the zero point of the difference index (or even manifest scores in the opposite direction), suggesting no congruence benefit for disgust emerged at all among individuals lower in disgust. Thus, it is possible that many of the effects in this thesis may have been driven entirely by those higher in trait disgust.

A consistent finding across the behavioural experiments (see chapters five, six and seven) was that disgust propensity increased the negativity associated with disgust targets (regardless of primes or prior exposure). This manifested in both reaction time measures and response data. This finding is not entirely surprising, but does emphasise the extent to which these individual difference measures do meaningfully alter assessments of disgusting stimuli, and indicates that although these stimuli were regarded as unpleasant (regardless of trait disgust), there is little doubt that the aversive stimuli were far more affectively impactful for individuals high in disgust.

Comparing the results presented in chapters six and seven reveals that trait disgust can modulate different early perceptual influences following exposure. The emotional priming paradigm in chapter six is reported to tap perceptual discrimination mechanisms (see chapter 3.2.2) – possibly through priming semantic activation (as indicated by Neumann & Lozo, 2012). However, whereas Neumann and Lozo (2012) found congruence benefits with subliminal primes, the results in chapter six found that disgust propensity and sensitivity both impacted primes that were on screen for an extended period. These results implied that some conscious processing of the disgust primes was necessary to facilitate the revealed effects. However, the direction of these results was that prior exposure to disgusting images resulted in a faster processing of a subsequent target image. This enhanced processing speed was not present in the results in chapter seven, thus suggesting that this emotional congruence effect was likely contingent on visual priming specifically, and processing benefits are not manifested by ruminating on disgusting information while engaging with disgusting stimuli. Extending this, the results of chapter six could be regarded (when put in context with the emotional priming literature) as a processing benefit for disgust primed disgust targets (among individuals high in disgust), whereas the pattern of results in chapter seven indicates that elaborative affective assessment is skewed as a result of a more affective disgust exposure. Although emotional *congruence* effects are referred to similarly in mood manipulation and priming studies, the way in which this congruence manifests is very different. The results in chapters six and seven are an indication that, in the context of visual priming, congruence effects appear to bias processing towards a relevant emotional category, whereas chapter seven indicates that congruence effects stemming from affective engagement with a negative emotion serve to make future emotional *assessments* of stimuli associated with that emotion more negative. While the latter effect is in line with previous research utilising mood manipulations (see chapter 3.2.1), the finding that no *processing benefit* emerges as a result of such congruence – in a task where it is conceivable that they could manifest (e.g. with faster classification of disgust images in the disgust exposure group) – is an indication that these discrepant forms of disgust exposure (brief primes and recalled sentences) are able to target discrete processes with a degree of specificity.

One important design difference between chapter six and seven was the response label used. Whereas chapter seven required a general assessment of unpleasantness (as the primary analysis was concerned with how it impacted food assessments), chapter six specifically targeted the disgust emotion (by asking whether the target image was disgusting or not). It is possible to speculate that the emotional specificity of this label resulted in the discrepancy in RT effects (see chapter 10.4.2 for a more in depth discussion of the potential consequences of the emotional response label) rather than the differences in exposure type; however, while the label itself may have had an impact on the results, there do not seem to be good theoretical reasons for accepting this as the sole reason for the discrepancy. Trial to trial sensory exposure (of the type present in emotional priming paradigms) is associated with biases to automatic processes (see Moors & De Houwer, 2006) that result in non-strategic and unintentional processing of a subsequent stimulus. In the context of chapter six, the current understanding of visual priming suggests that the faster responses to disgusting targets (following disgust primes) were not a result of conscious direction, even if the primes were consciously perceived.

Emotional exposure that targets a pervasive affective experience of an emotion, such as that used in chapter seven, is more in line with the mood manipulation literature (see chapter 3.2.1), though it is important to note that the cognitive component of the manipulation (requiring participants to remember sentences) distinguishes it from the task-free affective exposure typically employed in this line of research (see chapter 10.4.1 for an expanded discussion of this distinction). With regard to their overall psychological effects, mood manipulations of this nature are speculated to influence *heuristic processing* (i.e. low effort cognitive shortcuts) in cases where the heuristic cue is affective, but also are speculated to predominantly influence *substantive processing* (high effort processing with substantial task demand) due to the necessary recruitment of cognitions that are *affectively infused* following such a mood manipulation (see Forgas & Koch, 2013 for an overview of this theory). However, when it comes to influences on processing more specifically, it is speculated that negative mood manipulations influence accommodation (rather than assimilation) processing strategies (Bless & Fiedler, 2006), which result in a greater reliance on environmental cues to guide processing, evaluation and behaviour. Bless and Fiedler (2006) argue that a negative mood serves the adaptive function of preparing us for an environment where hypervigilance to external events may be beneficial to the individual. With regard to chapter seven, due to the extent to which they rely on fast (and possibly automatic) processes, the responses in the task may not have tapped the substantive processing mechanisms described by Forgas and Koch (2013). However, this disgust manipulation may have facilitated an increased accommodative processing strategy, and resulted in a hypervigilance towards disgusting stimuli. As chapter six revealed a reduced response time to disgust targets, the absence of these effects in chapter seven, interpreted through the lens of Bless and Fiedler's (2006) *assimilation-accommodation* theory, implies that negative mood may have resulted in an enhanced perception of the unpleasant qualities within the disgust stimuli, but that this enhancement did not affect processing speed. Instead, it was the evaluative functions that were primarily affected (with participants assessing disgust images as more disgusting following exposure). Thus, if there is an adaptive benefit from such a processing strategy following this mood manipulation, it may manifest primarily through heightening the subjective negativity associated with such aversive stimuli, rather than facilitating an increased ability to detect or identify it.

Disgust propensity, in higher levels, was the variable that appeared to generate these exposure effects in participants. With reference to Bless and Fiedler (2006), this may imply that disgust propensity is a facilitator of an accommodative processing style that serves the adaptive function of outfitting the individual with an increased ability to evaluate threatening information in the environment after experiencing disgust. In light of this, one interesting finding was that the effects in chapter seven were driven entirely by disgust propensity, not sensitivity (indeed, only chapter six revealed exposure effects related to disgust sensitivity). Given that disgust propensity is associated with second order processing of stimuli (i.e. processing that primes behaviour and results in cognitive appraisal after the initial detection of a stimulus; Borg et al., 2012), this is in line with the suggestion that the tendencies facilitated by disgust propensity affect ongoing interpretation of stimuli rather than its detection.

On a more cognitive level, negative mood can override the tendency to form assessments based on irrelevant information that draws on internal biases (e.g. Forgas, 2011); however, on a perceptual level, negative mood is reported to encourage hypervigilance to environmental stimuli (Schwarz, 2010). Given this, it is worth noting that the tasks constructed in this thesis were contingent upon individuals actively engaging with stimuli, and were explicitly designed to minimise the extent to which existing cognitive biases could influence the results. If a negative mood is associated with an increased tendency to process information using stimulus driven bottom-up mechanisms, it is difficult to speculate as to how tasks particularly dependent on bottom-up assessments (with limited opportunities for utilising processing based on existing internal beliefs or biases) will be impacted. Nevertheless, given the finding that disgusting stimuli were evaluated more negatively after disgust exposure (among individuals high in disgust propensity), a finding repeated in the post hoc analysis in chapter eight (see chapter 8.3.7), along with the findings related to non-disgusting stimuli (discussed in chapter 10.3.1.2), the data in this thesis support the notion that an increased disgust propensity alters evaluative assessments following disgust exposure – a finding that is consistent with the notion of negative mood acting to skew participants' judgements towards negative valence, and to facilitate increased processing of disgusting stimuli in the environment.

The only experiment in which disgust sensitivity (rather than propensity) modulated responses to disgusting stimuli was in the visual priming experiment in chapter six. In this case, disgust sensitivity was associated with the same increasing congruence benefit (for disgusting images preceded by disgusting primes) as disgust propensity was (albeit with a smaller effect size). Given that disgust sensitivity is more associated with detection and initial response to disgusting stimuli than disgust propensity (Borg et al., 2012), this paradigm – in which rapid perceptual mechanisms were necessary to process the disgust primes (and thus to be affected by the induction method of this experiment) – may have been the only one that drew on the early perceptual mechanisms disgust sensitivity is able to modulate. However, given that these priming effects were also moderated (and to a stronger degree) by disgust propensity, disgust sensitivity could be considered a slightly redundant variable across the work in this thesis. The extent to which propensity and sensitivity are independently predictive constructs is still a subject of debate, but given that the studies published in experimental psychology that use similar paradigms to the ones in this thesis, and that have required a marker of trait disgust, have predominantly used measures of disgust propensity (largely as a result of the more commonly used questionnaires exclusively assessing this construct), this thesis may suggest that the perceptual and evaluative mechanisms that manifest within these paradigms are more strongly determined by disgust propensity.

In discussing why the DS-R was used in a study, rather than the DPSS-R, Berle et al. (2012) highlighted circularity in the questions related to disgust sensitivity, as well as conceptual overlap with items appearing to represent anxiety rather than disgust (e.g. "it scares me when I feel faint"). The latter point is important as disgust sensitivity is speculated to be reflective of emotional sensitivity more generally (Goetz et al., 2013; Olatunji, Moretz, et al., 2010). For the work in this thesis, it is possible to hypothesize that the specificity with which disgust effects manifested may have weakened (or in some cases eliminated) disgust sensitivity (relative to propensity) effects. However, the results would seem to prohibit the explanation that this was because disgust sensitivity was responsive to emotion (or valence) more generally (rather than to disgust specifically). If this was the case, then disgust sensitivity would have modulated responses to emotional (over neutral) stimuli, and would have done so for fear stimuli as well as disgust as a result – a notion inconsistent with the results in this thesis. Although it is possible to marshal potential explanations as to why the disgust-specific effects in this thesis were more strongly related to disgust propensity, rather than sensitivity, it may simply be the case that disgust propensity (or generalised disgust as it has also been represented in the literature) is a more reliable construct that manifests cognitive and behavioural effects more consistently. Given that the animal reminder and contamination subscales of the DS-R also appeared slightly redundant to the findings in chapter six, it may be that general disgust propensity is the most valuable trait disgust variable for researchers seeking to explore the relationship between disgust exposure and subsequent disgust processing. Despite these lingering theoretical issues, the work in this thesis clearly demonstrates that this disgust propensity variable does indeed play a sizeable and important role in modifying the perception and assessments of disgusting stimuli in the environment.

10.3.1.2. Trait disgust's role in processing non-disgust images following exposure.

The work in this thesis did not implicate disgust propensity's role in processing exclusively disgusting stimuli (following disgust exposure), but also demonstrated that stimuli not considered explicitly disgusting could be impacted in a similar direction. The most important finding in chapter seven was that disgust propensity appeared to slow responses to food images, and resulted in a higher disgust assessment of them, following disgust exposure. This is particularly significant as the core contrast in this chapter was not with neutral stimuli (as in many other experiments), but other similarly positive emotional scenes. This was evidence that individuals high in disgust propensity have a more negative response specifically to food images after having been exposed to disgust – and reinforces the commonly referred to notion that disgust can reduce the appeal of food. These results were entirely driven by disgust propensity (rather than sensitivity) and this does appear to be in line with previous research that has explored the link between disgust propensity and appetite. Herz (2011) found that disgust propensity (but not sensitivity) was associated with sensitivity to taste; similarly, Chu et al. (2015) found that symptoms associated with eating disorders were exclusively predicted by disgust propensity. Given that the insula is considered to be the seat of the primary gustatory cortex (Pritchard et al., 1999), as well as the neural structure most consistently associated with disgust processing (see chapter 1.4), it could be speculated that the more specific association with disgust activation for disgust propensity (rather than the potentially more general emotional activation associated with disgust sensitivity) drove this relationship.

However, functional imaging studies on disgust propensity could also indicate that it was disgust propensity's ability to affect the broader network associated with evaluating food that drove these effects. Although Borg et al. (2012) found that disgust sensitivity (but not propensity) was associated with increased insula activation in response to perceiving disgusting stimuli, disgust propensity facilitated the coupling between the insula and cortical areas. The coactivation of the insula along with areas of the prefrontal cortex (primarily those associated with cognitive control) is also found in the normal processing of food stimuli (García-García et al., 2013). Calder et al. (2007) did not take a marker of disgust sensitivity, but found that disgust propensity increased activity in the insula to food images that were regarded as disgusting, thus suggesting that disgust propensity can modulate the insula's responses to food images (even if high levels of disgust propensity are not associated with increased insula activity for disgusting stimuli). Putting the results in chapter seven together with this neuroanatomical literature, it is possible to speculate that disgust exposure modulated the insula's response to food images amongst those high in disgust propensity (such that the food images were perceived as more disgusting), though the result may also have been driven by disgust propensity's ability to affect the wider network associated with regulation of appetite and eating restraint. In the absence of fMRI studies examining the processing of either disgust or food images following disgust exposure, it is difficult to extrapolate strong conclusions as to the specific aspects of the network associated with food images that are being impacted by such a manipulation. However, the finding in chapter seven that disgust propensity alters food assessments (relative to other pleasant stimuli) following disgust exposure is one that is in line with our current understanding of both the function of trait disgust, and the neural processing of food images, and further implicates disgust's role in food evaluation by revealing that it can lead to an aversive reaction to pleasant food images as well as to disgusting food images.

Disgust propensity was also associated with an interesting result for the fear and neutral LPP comparison in chapter eight. This finding is best interpreted as an increased LPP for neutral following disgust exposure and is in line with the other (non-disgust related) disgust propensity results in carrying the implication that, following disgust exposure, higher levels of this variable can prime emotional perception more generally. In this case, disgust propensity augmented the later LPP windows (600-1000 ms post stimulus onset) through effectively raising the baseline (i.e. the response to the neutral images). It is important to note that the LPP for both fear and disgust was significantly enhanced over neutral in this window despite this disgust propensity related neutral increase – with increased disgust propensity resulting in a diminishing gap between fear and neutral. The existing body of literature provides no reason to suspect that this finding could be indicative of non-emotional neutral stimuli having any particular emotional significance to those high in disgust propensity (that is brought out after prior disgust exposure); the interpretation that individuals high in disgust propensity (who have been exposed to such a disgust manipulation) are simply hypervigilant to future stimuli encountered in the environment and thus have an increased LPP for even non-emotional stimuli, is an explanation that is more parsimonious with the other results in this thesis, the body of literature on disgust, and of emotion processing more broadly. This explanation is more plausible given that the nature of the task was such that participants were explicitly directed to assess the emotional content of the images before seeing them. Given that fear (and disgust) stimuli provoke a large LPP regardless of exposure, the lack of further augmentation for those with high disgust propensity may indicate a ceiling effect for such aversive stimuli that is not present for neutral (which does not typically increase the LPP, and traditionally serves as a control for emotional effects in these ERP studies).

As the LPP is typically interpreted as indexing attentional allocation (see chapter 4.2.8), this finding could imply that disgust exposure results in a pre-allocation of attentional resources before the content is identified in those who have high disgust propensity. The results in chapter seven indicated that such stimuli as food images – that can, under some circumstances (such as when it is spoiled), arouse an appropriate disgust response – are able to provoke an increased disgust reaction (depending on disgust propensity) even when the food in question is evaluated as pleasant outside of the task. The results in chapter eight suggest that disgust propensity can also recruit attentional resources in anticipation of processing potentially aversive stimuli. That this effect manifested in the 600-1000 ms LPP window – a window associated with increased top-down control –, is a further indication that these effects may have been more driven by the individuals' attentional allocation, rather than by the properties of the stimuli. Across these two chapters (seven and eight), the findings bolster the tentative hypothesis that disgust propensity serves to divert attentional resources to aid in the processing of potentially aversive or threatening information in the environment.

These effects strongly associated with disgust propensity were (as with the disgust-specific effects outlined in chapter 10.3.1.1), generally not related to the disgust sensitivity variable drawn from the DPSS-R. Regarding disgust sensitivity, as has already been discussed, taken as a whole this thesis would seem to indicate that disgust propensity is the variable that is likely of primary interest to this line of research. When effects were associated with disgust sensitivity (as with those in chapter six), they mirrored those of disgust propensity, but were weaker in effect size. Disgust sensitivity's ability to modulate perceptual outcomes following disgust exposure was confined to the results in chapter six; as a result, disgust sensitivity was not associated with perceptions and evaluations of non-disgust stimuli across this thesis. Even if the visual priming mechanisms in chapter six are able to be influenced by disgust sensitivity, outcomes that extended beyond emotional priming congruence effects were lacking. Disgust sensitivity may have the capacity to influence a number of other psychological variables (see chapter 2.5), but it does not appear to be strongly associated with moderating the link between disgust exposure and short-term affective experience. It is possible that as disgust propensity is the variable speculated to facilitate the link between the insula and broader cortical regions (see chapter 2.10), it could be the variable capable of uniquely marshalling attentional and cognitive resources following disgust exposure to augment processing of subsequent stimuli. The ERP findings in chapter eight are consistent with this notion.

This thesis has clearly demonstrated that, following disgust exposure, disgust propensity aids in the detection of disgust (chapter six) as well as increasing the disgust associated with such stimuli (chapter seven and eight); however, the thesis also demonstrates that disgust propensity influences evaluations of food (chapter seven), and possibly also that it increases attention towards stimuli more generally when an affective assessment is required (chapter eight). Put together, these results do indicate that a variety of perceptual and evaluative mechanisms are affected by disgust propensity. Disgust propensity is traditionally associated with outcomes related to personality, beliefs and values (see chapter 2.9); this thesis adds support to the notion that this variable, along with affecting how we think about the world, can also hold a substantial sway over how we perceive it.

A unique contribution of the work in this thesis is in highlighting that differing levels of disgust propensity do not simply influence the way evocative stimuli are perceived and evaluated in isolation, but also influence the ways in which expectancies and perceptual tendencies are impacted by prior exposure to disgust. Rather than merely impacting emotional assessments to stimuli without context, disgust propensity appears to be a variable that can attune an individual's ongoing, short-term, affective processes on the basis of recent emotional experience. Although, in operating in this manner, disgust propensity may lead to more negative responses to otherwise pleasant entities (such as food in chapter seven), it is not difficult to see how, through these mechanisms, high levels of disgust propensity could confer an adaptive advantage in dealing with potentially hazardous environments.

10.3.2. Attentional control's moderation of emotional ERPs after disgust exposure.

Whereas disgust propensity appeared to result in an increased emotional response following disgust exposure, the two ACS attentional variables exerted a more complex pattern of exposure related effects across this thesis. These attentional variables did little to alter the exposure effects in the behavioural experiments, but drove the electrophysiological exposure effects. As the behavioural paradigms in this thesis undoubtedly tapped attentional mechanisms it is interesting that these experiments were not affected by attentional control. Attentional focus was a variable speculated to reduce priming influences in chapter six; however, these disgust specific congruence effects appeared only to emerge for individuals high in disgust propensity and sensitivity. Amongst individuals lower in disgust these priming influences did not appear to manifest at all, thus indicating that for many participants priming effects did not emerge – and as a result, attentional focus had no effects to moderate. More interesting are the lack of attentional effects in chapter seven. This experiment used a variant of a disgust manipulation that has been previously found to be strongly moderated by attentional control (van Dillen et al., 2012); however, the most striking effects in chapter seven came in the ratings data, which was not affected by attentional control. Van Dillen et al. (2012) found that attentional control moderated evaluative influences following disgust exposure, but clearly chapter seven would indicate that this effect does not carry over to emotional evaluations of visual stimuli. Given the interpretation that attentional control facilitated emotional disengagement with the disgusting scenarios in van Dillen et al. (2012), it is possible that a task such as that used in chapter seven (which required multiple emotional evaluations of stimuli) prohibited this emotional disengagement. Although differences in attentional control modulated responses to stimuli in this experiment, they were not related to prior disgust exposure.

Unlike the behavioural experiments, the exposure effects in the ERP experiments were strongly influenced by attentional control. Specifically, the LPP was affected by these attentional variables in both chapter eight and nine – a finding not particularly surprising given the attentional mechanisms represented by the LPP. However, the attentional effects in chapter eight and nine were manifestly different. Attentional shifting reduced the LPP for both disgust and fear in chapter eight, thus suppressing the emotional related deflection, but was not able to exert this suppressive influence when participants were exposed to disgust. In contrast, after disgust exposure, attentional focus actually increased the LPP to disgust in chapter nine. This discrepancy in results may be more contingent on the differences in the disgust exposure manipulation (an issue discussed in more detail in chapter 10.4.1), but nevertheless, these results have implications for the ways in which attention augments emotional perception following such exposure.

The manipulation used in chapters seven and eight was the one that was hypothesised to produce exposure effects that were dependent on the ability to shift attention. Although no attentional shifting effects emerged for chapter seven, ERP methods allow a determination of whether processing has been impacted even in the absence of response time or explicit evaluative responses. The chapter eight results may be interpreted as attentional shifting ability enabling individuals to engage with the emotional assessment task while retaining the sentence information in working memory. Under this interpretation, disgusting sentences either served to prime affective responses to subsequent scene images through prior (and recent) emotional activation (to the extent that shifting capacity was not able to exert a suppressive influence as it was in the neutral exposure group), or were associated with a higher working memory load than the neutral sentences. Given the extent to which the sentences were controlled between exposure groups, this latter interpretation is only possible if the increased affective processing associated with storing, recalling and retrieving the disgust (rather than neutral) sentences had an effect on the working memory load associated with these scenarios. Given the different pattern of results between chapter eight and nine, and given that working memory load has been demonstrated as having a suppressive effect on the emotional LPP (MacNamara, Ferri, et al., 2011), the former of these interpretations seems less likely – as the manipulation in chapter nine should also have primed disgust activation in participants, but attentional shifting was not found to modulate the LPP (in either exposure group) in this experiment.

Regarding the attentional control influences in chapter nine, attentional focus actually appeared to increase the LPP associated with disgust stimuli following disgust exposure. Although attentional control is associated with *behavioural* performance in tasks (at least for paradigms that depend upon attention), ERP data tends to be associated with specific perceptual processes that, while potentially giving rise to the successful completion of many cognitive psychology experiments, do not necessarily directly reflect task performance per se (with the exception of very paradigm specific components such as the P3b and the N2b discussed in chapter four). The LPP was selected in this experiment (and in chapter eight) as it is a reliable marker of emotion processing that indexes many of the processes that give rise to an emotional assessment. However, the LPP more generally reflects the recruitment of attentional resources for processing – resources that are potentially automatically recruited when emotional stimuli are viewed (as discussed in chapter 4.2.8). Unlike behavioural experiments, the task in this experiment did not hinge on rapid emotional classification – the timings were such that, on the trials where a response was required, the prompt occurred after the cut off window for analysis (and after the stimulus had been on screen for over a second). Thus, the rapid attentional orientation mechanisms required to (for example) quickly identify a stimulus were not recruited in this experiment. The task in chapter nine did however explicitly instruct participants to actively engage with, and concentrate on, the emotional content of the stimuli. In such a paradigm, where the vast majority of trials required no response, staying engaged with the stimuli – to the extent that the emotional content is still being consciously processed – may require attentional focus. Given that the disgust specific

LPP modulation (following disgust exposure) among those higher in attentional control was most strongly manifested in the earliest window – one in which both top-down attentional resources *and* the stimulus driven emotional properties of the stimuli may additively influence (see chapter 4.2.8) – this modulation may reflect the shifting of attentional resources to actively engage with the decoding of the emotional properties of the stimuli.

As was previously discussed (see chapter 9.4.1), the fact that this effect emerged only for disgust is in line with previous research using a nearly identical disgust manipulation (Hartigan & Richards, 2016) and suggests that disgust exposure increases the LPP to specifically disgusting stimuli. In line with the interpretation that attentional focus facilitated continued emotional engagement with the stimuli (as a result of following the task instructions without attention wavering), and in line with the notion (demonstrated by Hartigan & Richards, 2016) that this effect only emerges in the presence of such emotional engagement, these results could indicate that disgust exposure increasingly primes individuals to process (specifically) disgusting visual information in proportion with the attentional resources they are able to allocate to an emotionally engaging process. Given the comparison between chapters eight and nine, this effect may only emerge when the disgust manipulation is a task-free disgust mood manipulation – possibly as this enables an increased allocation of attentional resources that would not be available if the manipulation itself drew on such resources (as it may have done in the sentence recall task in chapter eight).

Disgust propensity was continuously associated with an increased emotional response to subsequent stimuli, but the pattern of results for attentional control was more varied. Nevertheless, these discrepancies likely reflect the discrepant processes that the paradigms drew upon, and the results in this thesis serve to elucidate the processes that are modulated by attentional control following disgust exposure. On the basis of integrating these results with the existing literature, the preliminary interpretations of these effects are that attentional shifting can reduce electrophysiological markers of emotion processing when resources are required for a concurrent task (chapter eight), whereas attentional focus can actually facilitate emotional engagement with stimuli, and thus increase disgust exposure effects, in cases where such engagement is explicitly directed and the manipulation itself does not directly interfere with emotional engagement with the stimuli (chapter nine). Although it is certainly possible to form alternative accounts for these findings, this interpretation is in line with the existing theory as to the mechanisms of the LPP, the consequences of emotional exposure, and the ways in which individual differences in attention can modulate performance in cognitive tasks.

The work in chapter nine in particular also expands upon Hartigan and Richards (2016) by suggesting that specifically disgusting stimuli, whether represented by faces or emotional scenes, may be subject to an enhanced emotional response following disgust exposure – and builds on this by indicating that this is dependent on individual differences in the level of emotional engagement with the stimuli.

10.4. Methodological Implications

10.4.1. Mechanisms of disgust induction.

One important finding in this thesis was that, although they represent exposure to the same emotional category, different disgust induction methods can produce very different effects. These discrepant exposure effects have been previously discussed, but they are summarised in this section with the implications for future research that has the goal of inducing disgust and exploring the consequences of the induction. There is ample evidence that exposure to disgust through still images is an effective disgust manipulation (see chapter 3.4.3); however, this is clearly distinguishable from the brief trial-by-trial priming used in chapters five and six, and likely produces very different consequences. The work in this thesis did not use still images to induce an affective or mood related disgust induction, and the brief disgusting images in chapters five and six functioned as visual primes that produced results similar to those in other emotional priming studies, rather than those more representative of the literature that could be described as examining "disgust exposure". Nevertheless, the finding that these emotional priming mechanisms are impacted by trait disgust (when disgust is the emotion participants are instructed to identify) does suggest that trial-by-trial priming with disgusting stimuli is disproportionately effective for individuals higher in disgust and thus carries important implications for any research utilising disgusting primes in visual priming research. This may not be considered to be a disgust induction as such, but clearly the individuals most likely to be impacted by disgust inductions (i.e. those high in trait disgust), are also those most impacted by disgust priming.

One important finding was that disgust induction through written sentences that are actively ruminated upon does not just influence the evaluative mechanisms that result in different subjective assessments of stimuli, but also influences the sensory-motor processes responsible for rapid emotional classification and the neural processing that occurs while emotional stimuli are being engaged with. Although there are studies that have manipulated disgust through written scenarios, it is unusual to require participants to actively keep these scenarios in memory across the experiment as was done in this thesis. Given that the less cognitively engaging written scenario approach was not utilised in this thesis, it is difficult to directly compare results. However, the pattern of results in chapters seven and eight clearly suggest that this method of disgust induction does not prevent disgust exposure effects emerging (it may even increase their potency – though it would take future research to establish this), but may impact participants' ability to manage attentional resources to deal with processing future stimuli of varying emotional content – as evidenced by the lack of ability for attentional shifting to modulate the emotional LPP following such exposure. This type of manipulation ensures that participants stay engaged with the content of the disgust exposure manipulation, but may also result in a reduced ability to direct attention to the next task.

Given the very similar designs in chapter eight and nine, the differences in results are likely to be largely dependent upon the type of manipulation used. The benefit of using a purely affective mood manipulation – such as exposure to intensely disgusting videos – is that there is little doubt that this impacts a range of processes (see chapter 3.4.2), but also allows participants to fully engage with the subsequent task. If the results of chapter eight suggest that a cognitively engaging disgust exposure can prevent participants' from marshalling attentional resources, chapter nine may suggest that a more affective task-free manipulation allows individuals to wilfully focus attention on the emotional content of the stimuli in a subsequent task – a behaviour that may lead to stronger exposure effects.

It is clear that the specific disgust exposure induction method is extremely important when it comes to generating specific exposure related effects (as also observed by David & Olatunji, 2011). It seems important to also note that it is not just that the method itself, but the ways in which an induction method can discrepantly impact different categories of experimental task. It is likely that there is no single *correct* method to induce disgust, but that the method selected should be highly dependent on the psychological processes that the task depends on and the specific question being addressed. Quick visual primes before experimental trials may be a good way to examine the extent to which disgust information can be inhibited by attentional control mechanisms, whereas more cognitively engaging affective mood manipulations may be a better way to explore how the qualitative feeling of being *disgusted* can impact emotional processing. The ways in which cognitive, affective and perceptual mechanisms are impacted following disgust exposure is a fairly recent subject that is still being explored; but it seems clear that these mechanisms are discrepantly impacted by different induction methods, and manifest different short -term consequences as a result.

10.4.2. Category labels in emotion identification studies.

Many emotion processing tasks in experimental psychology require participants to identify the emotional label that corresponds to a particular image – typically these labels correspond to the basic emotional categories. As has been previously discussed, it has been demonstrated that the choice of emotional label has an impact on the assignment of emotion within a task (Pochedly et al., 2012). The work in this thesis used binary response labels throughout – with an affirmative response indicating that a stimulus evoked a particular emotional response (being either specifically *disgusting*, or *unpleasant* more generally). The alternative (negation) response in these experiments indicated that the stimulus was not representative of that emotion or emotional category, rather than indicating that it was representative of a different specific emotional category. This may not solve the problem with forced choice designs, but it does ensure that emotional categories that are not represented by a particular target stimulus are not arbitrarily assigned to another emotional category instead (such as with research where responses are restricted to a small set of emotional labels).

However, it is likely that the choice of emotional category did have a specific effect on the results in this thesis. Chapter six used a visual priming paradigm, but opted to target one specific emotional category (disgust). Neumann and Lozo (2012) used a similar design but included a binary *fear* or *disgust* response option across experiments (with only those two categories included in the stimuli set). This approach is useful for assessing participant's ability to assign the images to these categories (and tapping the activation of the schema associated with each emotional label); however, being more of a classification exercise, it may not specifically tap the subjective affective responses to such images. For example, it is possible for a stimulus within the set to evoke neither disgust nor fear in some participants, but the response labels would ensure that such a stimulus would be assigned to one of these categories regardless (possibly whichever label it was regarded as being closer to by the participant) – and in such a case would likely be done so on less affective grounds. Specifically assessing stimuli for disgust in chapter six enabled participants to identify such ambiguous stimuli as simply *not disgusting*. By targeting one specific label in this way, it is possible that the disgust-specific effects that were present were able to emerge.

A more general unpleasant label was used in subsequent experiments – as these experiments were interested in examining whether disgust exposure was associated with a greater emotional negativity towards specific emotional categories (that were not based exclusively on emotional congruence as they were in chapter six). If a "disgust" response label was used in these experiments instead, this may have prevented more general emotional effects being present in the data – as a result of participants classifying only the disgust stimuli (which were easily delineated from the other stimuli) with the disgust label. As a result of this, it may not be possible to generalise the results here to paradigms that used different response labels.

The notion that, within such experiments, effects are dependent on the choice of response label is one that has been clearly demonstrated in ERP research. Both Kisley et al. (2011) and Rehmert and Kisley (2013) found that the valence present in the response labels effectively framed the visual stimuli and produced a congruence effect (such that, for example, negative labels increased the LPP to negative images). In the case of the ERP experiments in this thesis, as pleasant stimuli were not included, the choice of an *unpleasant* response label likely did not augment one of the categories of interest (disgust or fear) over the other (though it may have done so over the neutral stimuli). However, it is also possible to speculate that participants were somewhat primed towards emotional negativity, regardless of exposure group, by virtue of the *unpleasant* response label being used. Given the type of contrast utilised (not comparing unpleasant and pleasant categories as many ERP studies have done), and given that disgust exposure effects did emerge, it is unlikely that this had a significant impact on the results. It is unclear what potential response options could be used to fully mitigate such framing effects (though many emotional ERP studies do not require responses at all and thus are less likely to be subject to these effects), but this previous ERP framing research clearly demonstrates that, when response label and stimulus category congruence occurs, it likely impacts ERP data. Given that examining the effect of response labels was not the purpose of this thesis, and such comparisons were not made, it is not possible to directly test these effects here. However, even though the response options within each experiment were selected in light of this literature, and with foreknowledge of these effects, it seems likely (based on the existing literature) that the effects in the thesis were (at least partially) dependent on such response options. As with disgust induction methods, it is becoming increasingly clear that the method of examining emotional response to visual stimuli, and the range of outcomes participants have to choose responses from, is an important part of how such stimuli are responded to. This does not necessarily present a problem for emotion research, but it could mean that it may be more difficult to generalise emotional perception experiments than has been previously assumed within the field, and it also suggests findings such as those within this thesis should be interpreted with reference to the response options selected. With regard to future emotion research, it may be beneficial to repeat experiments using different response options in order to shed further light on the processes these paradigms can draw upon and to determine the extent to which broad emotional results are generalisable.

10.4.3. A brief discussion of inconsistencies in emotional scene image use.

One of the unexpected outcomes of this thesis was the failure to find an emotion related EPN deflection. There are published studies that appear to have failed to find an EPN deflection for negative stimuli (for example, Pastor et al., 2007), even though this is not always stated in the text of the article. As has been previously discussed (see chapter 8.4.3) this is unlikely to be a result of the paradigm, but may be related to the included stimuli. Given that most of the aversive images used in this thesis (both disgusting and threatening) were not drawn from IAPS, it is possible that this inconsistency with the stimuli commonly used in much of the published literature resulted in the discrepancies with this component. However, it is worth noting that there does seem to be substantial variability across studies when it comes to (for example) valence modulation within specific emotional ERP components (a subject discussed in the ERP section of chapter four) and this may result from stimuli selection. Weinberg and Hajcak (2010) demonstrated that the inclusion of particular emotional subcategories of stimuli within the IAPS database influenced whether valence effects emerged; in addition to this, it is apparent that many of the IAPS images within the same category also differ on many other structural grounds (such as picture complexity).

When representing emotional valence categories (or even specific basic emotional categories), it is difficult to determine on what other criteria stimuli should be matched across emotional groups. Stimuli categories are often matched on criteria such as emotional arousal in order to preclude any confounding effects. However, if the purpose of this is to ensure that ERP comparisons between categories genuinely represent emotional (rather than arousal) effects, then it is not entirely clear why neutral image categories must not also be matched for arousal. Clearly such a match would not be possible – as neutral images that were emotionally arousing would not be neutral –, but it is unclear why comparing a pleasant or unpleasant set to a neutral one should be considered an emotional, rather than an arousal related, effect given this rationale. A further potential issue comes with generalising findings from emotional scene research beyond the experiments. If categories such as *disgust* and *fear* are to be used within an experiment to represent the emotional categories as they exist (and are referred to) outside of the lab, then it seems a non-trivial decision to exclude a subset of such stimuli that indisputably embody these categories on the grounds that they are too different (in other criteria) to stimuli in other emotional categories. Although this process will result in stimuli that are more consistent across groups, it may also artificially create emotional subcategories that do not accurately reflect the categories they are being used to represent. It is possible to make the argument that there is no reason to assume that (for example) disgusting and fear-inducing images should generate equivalent levels of emotional arousal given the different patterns of physiology and behavioural tendencies they provoke. This is particularly pertinent given that one of frequently cited reasons for using emotional scenes instead of other stimuli types is that they are more representative of imagery as it can actually be encountered in everyday life. In light of this, although there may be good reasons to ensure that stimuli are not confounded on affective grounds, matching these stimuli too closely on grounds that are not solely related to either the structure or composition of the images may artificially narrow affective differences that actually exist between these emotional categories as they are encountered outside the lab.

Whether these stimuli matching procedures are useful may hinge on the ways in which emotions are conceptualised – in particular, whether the commonly referred to emotions are holistic *basic* categories, or emerge from discrepancies in other affective criteria such as *core affect* (see chapter one). However, matching emotional stimuli on less affective grounds would appear to be less contingent on adherence to particular theories of emotion. As was discussed in chapter 4.3.2, there are reasons to assume that variables such as picture complexity and the presence (or absence) of facial expressions could meaningfully alter the perception of these images. Interestingly, in contrast to affective variables such as *arousal*, these structural variables appear to be matched (between emotional categories) very inconsistently across the literature. Weinberg et al. (2012) explicitly address the human faces confound in text, and ensured that all categories within the experiment included human images so that these effects would balance across groups. The work in this thesis used the alternative approach of removing all images of human faces from the experiments. However, there are published studies that include scene images (from IAPS) that centre on the facial expression of individuals within one stimuli category but not in the others. Although within some studies this appears to be an implicit confound (that is to say that it is only discernible upon examining the specific images that were used), this discrepancy is explicitly referenced in some studies when the stimuli are described – such as when studies report that the *pleasant* category includes happy facial expressions, but do not list negative facial expressions as a subcategory of the *unpleasant* images.

In light of research that has found additive ERP deflections for faces overlaid onto emotional scene backgrounds (Righart & de Gelder, 2006, 2008), there is reason to suspect that inconsistencies between the content of the background of emotional photographs may also influence ERP results. To give an example, within the IAPS database, one image that has been used to depict a "neutral" expression depicts a judge seemingly passing sentence (see IAPS picture 2221). Although the facial expression itself may be considered to be neutral, the context of the image may provoke different emotional responses compared to other images where there is no such ambiguous context (or indeed a discernible background at all) to accompany the expression (see, for example, IAPS pictures 2107 and 2200, which are also commonly used). Regarding negative images, it is possible that facial expressions of negative valence with a clearly negative accompanying context (see IAPS picture 6312) are processed differently from negative expressions without such a background (see, for example, IAPS picture 2122), but both these images are frequently used to represent a broad *unpleasant* category. It is not simply that these scenes include faces, but that some of the face centred scene images include a context that must require additional processing (and potentially more shifts of spatial attention to the various focal points) in order to decode the emotional content of them (relative to a context free scene with a facial expression). Given that the LPP in particular is driven by top-down as well as bottom-up processes, it is possible that scene images that require a layer of contextual processing in order to facilitate an emotional response are processed differently from images that depict a simple, easily identifiable, emotionally evocative entity (such as, for example, a snake).

It is not clear whether these potential confounds actually manifest different ERP results within the same emotional category – although it is difficult to conceive of how images of human faces will not at least elicit an N170 deflection, regardless of emotion, that is not present for the other scenes. However, given that the range of stimuli used across studies varies considerably, it is entirely possible that some of the inconsistencies that are observed are partially attributable to this. It seems particularly unclear why, when using scene images, it would be beneficial to represent emotional categories largely utilising facial expressions that are presented against a blurred or non-descript background within the IAPS database – as these images are not as well controlled as the images in specialised facial expression depositories. If the purpose of using scene images, rather than faces, is to provide more heterogeneous and environmentally realistic emotional stimuli that tap affective responses, rather than emotional identification or motor representations, then composing these categories predominately using facial expressions precludes this benefit, and it may be better to use facial expression stimuli (from specialised repositories) instead. Whether or not components such as the EPN are dependent on the inclusion of emotional scenes with particular structural or affective characteristics is unclear, but it does seem plausible that inconsistencies across the literature could be driven partially by the inconsistencies in stimuli selection outlined in this section. Based on the rating data across experiments, the stimuli used in this thesis very clearly evoked the intended emotions in participants with a reasonable degree of specificity; however, in predominantly using aversive images that were not drawn from IAPS (although they depicted emotional elicitors concordant with those in the IAPS database), it is possible that some discrepancies in findings (compared to the existing literature that has used exclusively IAPS scenes) emerged as a result.

10.5. Future Directions

The work in this thesis has revealed new ways in which disgust exposure can influence subsequent emotional processing and shed a light on the perceptual mechanisms that are impacted. In highlighting these effects, some new avenues for future research appear to be opened. This section does not provide a comprehensive assessment of future research directions (though suggestions for future experiments to bring clarity to some results are provided in the discussion sections of chapters five to nine), but outlines what appear to be the main areas of investigation that could follow on from the work in this thesis (in conjunction with the existing literature) to substantially enhance our understanding of disgust exposure.

Firstly, the work in this thesis focussed exclusively on disgust exposure, but it would be valuable to examine the extent to which these effects could be brought out by exposure to other emotions. Disgust is an emotion with an unusual autonomic manifestation that has been demonstrated to affect ongoing processes in an atypical way (with a slightly delayed but persistent disruption); however, it is not entirely clear to what extent the effects in this thesis were driven by disgust exposure specifically, or could be attained by exposure to other aversive emotions. In particular, given the specific stimuli used across experiments in this thesis, it would be useful to examine the extent to which disgust propensity modulates emotion processing following fear exposure. The exposure effects that were specifically related to subsequent processing of disgust (rather than other emotional) stimuli (see chapter

10.3.1.1) could be speculated to be driven by congruence, rather than the specific properties of disgust exposure. That these effects were contingent upon levels of disgust propensity may be an indication of their disgust specificity, but it would be useful to repeat some of these experiments using a fear, rather than a disgust, induction. If, following such a fear manipulation, specific perceptual and evaluative biases were to emerge specifically for disgusting stimuli – that were contingent on disgust propensity – this may be an indication that disgust propensity calibrates individuals' perception towards disgust as a result of feeling unpleasant or emotionally negative more generally. If fear exposure led to preferential processing of specifically fear (rather than disgust) stimuli, this would be an indication that disgust propensity facilitated processing biases that were congruent with recent emotional experience. Given that chapter six revealed no congruence benefits for fear targets preceded by fear primes for individuals high in disgust (albeit in a study that explored emotional priming mechanisms and targeted the disgust emotion specifically with the response label), the former of these two potential outcomes would seem to be the more likely of the two. Although disgust propensity is predictive of disgust related avoidance behaviours (van Overveld et al., 2010), and appears to impact processing of disgust stimuli (as this thesis reveals), it is also related to outcomes that may not be specifically related to disgust (such as spider phobia in van Overveld et al., 2006). From the results in this thesis, it is clear that disgust propensity is strongly related to the consequences of disgust exposure, but examining whether this variable is also associated with consequences that result from exposure to other negative emotions would be extremely valuable in aiding our understanding of both the ways in which disgust propensity influences behaviour, and the ways in which emotional exposure functions more generally.

A more complicated research direction would be to attempt to integrate the literature on the more perceptual influences of disgust exposure with the more cognitive outcomes. Given that disgust exposure has the potential to disrupt processing to other tasks and influence future emotional perception, as well as altering elaborative cognitive functions such as moral assessment, it would be useful to try to develop an integrated account of how disgust exposure operates. Although achieving this would likely be difficult, there are some simple experiments that would help illuminate aspects of this. Namely, it would be extremely useful to determine whether individuals who are more sensitive to the perceptual influences of disgust exposure (potentially those high in trait disgust – though there may be other unexplored moderating variables) are also susceptible to disgust manipulations that affect moral judgement. A great deal of research in psychology focuses on the immediate responses (whether behavioural, physiological or neural) to emotional stimuli, and it is worth noting that although emotions are often conceived of (within psychology) as immediate responses to specific environmental triggers (see chapter one), their manifestation appears to also result in a temporary change to perceptual and physiological processes that affects how new information is responded to. The ways in which these short-term changes alter the processing of information in the environment could potentially be equally valuable in determining the specific functions of emotions. It is easier to speculate as to why exposure to disgust should alter subsequent emotional detection and evaluation (largely due to its proposed role in ensuring contaminants in the environment are avoided) than it is to speculate as to why disgust should influence moral judgement – a process that seems (at least superficially) to be far removed from this primary role. Determining whether disgust exposure alters different processes in different individuals, or whether these perceptual and cognitive consequences of disgust exposure covary – thus revealing that certain individuals are holistically more affected by disgust exposure – would be an extremely valuable (and achievable) first step and would substantially aid in our understanding of the function of disgust.

Finally, chapter seven in this thesis appeared to indicate that disgust does indeed play a role in the processing of food. Given that there appears to be a commonly referred to link between disgust and food in western culture (see, for example, Miller, 1997, for a discussion of this issue), there appears to be very limited experimental psychology research that illuminates the mechanism underpinning this link. Though some researchers have explored the link between taste and trait disgust (Herz, 2011, 2014b), there appears to be a substantial gap when it comes to the link between disgust and the perception and evaluation of the pleasantness of food. Although chapter seven provides preliminary evidence for such a link, there are several ways in which this could be explored in such a way that it would aid our understanding of the relationship between disgust exposure and the perception and evaluation of food. Most importantly, it would be useful to determine whether this relationship is confined to subsets of food stimuli. Many of the food images from the IAPS database that are regarded as pleasant appear to contain the seeping and wet qualities that Oum et al. (2010) determined as a crucial for disgust attributions to be made (for example, images of melted chocolate in desserts). It is possible that images of edible substances that are more solid would not be evaluated negatively following disgust exposure. That is to say that it is a possibility that it is the fact that certain food items share these characteristics with other disgusting entities that leads to them being evaluated more negatively when individuals are primed for disgust. Alternatively, if these effects were found to apply to all food stimuli (regardless of superficial structural characteristics), then it may be evidence that disgust does indeed specifically reduce the tendency to find edible substances appealing regardless of their physical qualities. Given that there has been so much discussion of disgust's function as a potential oral expulsion mechanism (see chapter one), it would be extremely valuable to experimentally investigate this by examining not only the consumption habits of people who have been exposed to disgust, but also their perception of food and the evaluation of how pleasant (or unpleasant) it is. This seems as though it would not be difficult to accomplish and would greatly aid in our understanding of one of the most fundamental functions of disgust.

10.6. Concluding Remarks

Among the emotions that tend to be studied with regularity within psychology, disgust does appear to be a particularly interesting one. While other negative emotions tend to provoke very clear behavioural responses (and accompanying physiological states that aid such behavioural tendencies), the role of disgust appears to be more difficult to decipher and its role has been conceptualised very differently over the years in which it has been investigated scientifically. Although the prevailing theory appears to affirm that disgust is a mechanism for avoiding environmental contaminants, why such a mechanism should also be found to be associated with the specific political, moral and interpersonal outcomes that it is remains a subject of controversy. What appears to be increasingly clear about disgust is that it has a substantial role in altering our short-term behaviour, and it is with regard to this aspect of disgust that the primary contribution of this thesis lies.

A wealth of research now exists to implicate disgusting experience in evaluative complex social assessments. On top of this very well publicised research, there is also a growing body of literature that implicates disgust exposure in disrupting attention and altering perceptual processes. This thesis primarily serves to illustrate that as well as influencing the ability to complete difficult attentional tasks (such as probe or letter identification), disgust meaningfully impacts emotion processing of stimuli within such tasks. To summarise the primary findings of this thesis (and the interpretations I have offered), with regard to perception and emotional classification, increasing levels of disgust propensity increase disgust congruence following briefly presented primes and slow the speed at which food images are responded to (relative to generally pleasant images) following disgust exposure. With regard to subjective emotional evaluation, disgust exposure can result in higher subjective disgust assessments of both food and disgusting images as disgust propensity increases. With regard to neural processing, task-free disgust exposure results in an increased emotional response to specifically disgusting stimuli that may be contingent on an individual's ability to engage with the emotional properties of such stimuli, whereas requiring individuals to persistently ruminate on disgusting imagery prevents attention related affective suppression of aversive emotional scenes. Outside of disgust exposure related findings, this thesis offered preliminary novel evidence for a disgust specific modulation of the parietal-occipital LPP which is not contingent on exposure, and may be evidence of a neural marker of disgust processing.

The overall thrust of these findings is that disgust exposure has a substantial effect on emotion processing, but that this is dependent on individual differences in both disgust propensity and attentional control – with disgust propensity directly influencing explicit responses to such stimuli, and attentional control markedly influencing neural processing. In this regard, the work in this thesis is of use to disgust researchers as well as researchers concerned with the effects of emotional exposure and the extent to which it varies between individuals. The work in this thesis supports the notion that disgust is an emotion that, as well as provoking an aversive and immunosuppressive response to specific unpleasant stimuli in the environment in order to prevent organism threatening contaminants, also appears to create a lingering tendency to evaluate subsequently encountered stimuli within the environment more negatively – a role facilitated by disgust propensity. In this regard, it is clear that the cascade of perceptual, psychological and physiological changes brought about by the experience of disgust does more than simply generate a response to a solitary disgusting object, but qualitatively impacts our ongoing perception of entities encountered in the immediate environment and our successive emotional predilections. The literature that has highlighted the myriad psychological effects of disgust exposure is relatively new, and the work in this thesis serves to illustrate that numerous emotional processes are also impacted by such exposure, and carries the implication that disgust holds more sway over our behaviours and processes than it is typically assumed to – with effects that infiltrate many of the processes we depend on to navigate the day to day environment.

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Appendix A

Selected IAPS Images

Ratings Task

Disgust images: 1270, 1271, 1274, 1275, 1280, 3150, 3213, 3250, 3400, 7078, 7920, 9008, 9031, 9140, 9180, 9181, 9182, 9183, 9184, 9185, 9186, 9290, 9291, 9295, 9300, 9301, 9302, 9320, 9322, 9340, 9373, 9395, 9405, 9561, 9570, 9571.

Fear images: 1050, 1051, 1052, 1114, 1120, 1200, 1201, 1202, 1205, 1220, 1230, 1240, 1300, 1301, 1304, 1321, 1525, 1726, 1820, 1930, 1931, 1932, 6020, 6190, 6200, 6230, 6260, 6263, 6300, 6610, 6800.

Food images: 7200, 7220, 7230, 7250, 7255, 7260, 7270, 7281, 7282, 7283, 7284, 7285, 7286, 7287, 7289, 7290, 7291, 7300, 7320, 7330, 7340, 7350, 7351, 7352, 7365, 7360, 7402, 7405, 7410, 7430, 7450, 7451, 7460, 7461, 7470, 7472, 7475, 7476, 7477, 7480, 7482, 7484, 7487, 7488.

Neutral images: 7003, 7004, 7006, 7009, 7010, 7017, 7018, 7020, 7021, 7025, 7026, 7030, 7035, 7041, 7042, 7043, 7045, 7050, 7052, 7057, 7058, 7059, 7061, 7080, 7081, 7090, 7100, 7140, 7150, 7160, 7175, 7179, 7190, 7211, 7233, 7235, 7512, 7705, 4950.

Pleasant: 1440, 1441, 1460, 1463, 1500, 1540, 1602, 1603, 1604, 1605, 1610, 1620, 1630, 1710, 1750, 1811.

Chapter Five

Disgust images: 3150, 3213, 3250, 3400, 9008, 9031, 9290, 9291, 9300, 9301, 9302, 9320, 9322, 9340, 9405, 9570.

Fear images: 1050, 1052, 1114, 1930, 1932, 6230, 6260, 6263, 7270, 7283, 7284, 7285, 7287, 7330, 7340, 7430.

Pleasant images: 5000, 5002, 5010, 5020, 5030, 5200, 5201, 5202, 5760, 5779, 5780, 5800, 5811, 5814, 5825, 7580.

Chapter Six

Practice images (neutral): 7014, 7018, 7081.

Disgust images: 3019, 3250, 9008, 9031, 9301, 9302, 9320, 9322, 9570.

Fear images: 1023, 1050, 1052, 1070, 1113, 1114, 1120, 1300, 1304, 1820, 1932, 6230, 6260, 6263.

Neutral images: 6150, 7003, 7004, 7006, 7009, 7010, 7012, 7016, 7017, 7020, 7021, 7026, 7030, 7035, 7041, 7042, 7045, 7050, 7052, 7053, 7057, 7059, 7061, 7080, 7090, 7136, 7150, 7165, 7175, 7179, 7190, 7192, 7211, 7233, 7240, 7950.

Chapter Seven

Disgust images: 3019, 3250, 9008, 9031, 9301, 9302, 9320, 9322.

Food images: 7287, 7330, 7351, 7390, 7430, 7470, 7487.

Pleasant images: 1731, 5000, 5010, 5020, 5199, 5200, 5201, 5202, 5210, 5480, 5594, 5660, 5665, 5700, 5711, 5720, 5725, 5726, 5750, 5760, 5764, 5780, 5780, 5781, 5800, 5811, 5814, 5820, 5825, 5829, 5891, 5910.

Chapters Eight and Nine

Practice images (neutral): 7012, 7042, 7052.

Disgust images: 3250, 9008, 9031, 9301, 9302, 9320.

Fear images: 1050, 1052, 1113, 1114, 1120, 1304, 1820, 1932, 6230, 6260, 6263.

Neutral images: 6150, 7003, 7004, 7006, 7009, 7010, 7016, 7017, 7020, 7021, 7026, 7030, 7035, 7045, 7050, 7053, 7059, 7080, 7090, 7150, 7175, 7190, 7211, 7233, 7950.

Appendix B

Exposure Sentences

Disgust

"As you start to fall asleep, you feel something tickling your lip and realise, too late, that a cockroach has crawled into your mouth."

"As you come home and walk through your front door, you notice a crackling noise as you step, you turn on the light and realise that the floor is covered with cockroaches."

"As you open your bin you notice that there are maggots crawling around inside."

"As you sit down on a bench in the park you notice a dead pigeon with maggots infesting the corpse."

"As you walk across your bathroom floor in bare feet you step on something, looking down you notice you have squashed a slug."

"As you are at a family birthday party, a relative's young child walks over to you with a squashed slug clenched in his fist."

"As you walk down an alley, you notice that you have stepped in a puddle of urine."

"As you are sitting beside a small child, they lose control of their bladder and urine spreads across the seat and into your clothes."

"As you are watching TV you notice something brushing against your ankle, you look down to see a rat running away."

"As you search in your loft for some tools, you disturb a nest of rats and they run away into a hole in the wall."

"As you sit across from someone on a train you notice that they have a spot on their face that has begun to leak."

"As a colleague goes to shake your hand you notice that they have a cluster of infected spots on two of their fingers."

"As you brush your hair the day after you help out on a school trip, you realise that it is full of head lice."

"As you sit down to have a haircut, you hear the hairdresser inform another customer that they are infested with head lice."

"As you finish mopping up a spill on your kitchen floor, you accidentally knock the bucket of dirty water over your feet and it soaks into your trousers."

"As you walk outside you accidentally drop your keys into a puddle of muddy stagnant water and have to reach in to get them."

"As you are talking to a friend they unexpectedly sneeze mucus in your face."

"As you are standing at a bus stop, a stranger loudly clears the mucus from his throat and spits it onto the floor."

"As you go into your living room one morning, you find that the sofa is covered with small ants."

"As you put your foot in your shoe, you notice that ants are crawling all over it."

"As you walk barefoot along a sandy beach, you accidentally step on a used condom."

"As you pick up some coins you dropped in the street, you accidentally pick up a used condom."

"As you wrap yourself in a towel after getting out of the shower, you realise that the towel has patches of mould all over it."

"As you look in the mirror whilst washing yourself, you notice that the flannel you are using is mouldy."

Neutral

"As you start to fall asleep, you feel something tickling your mouth and realise, too late, that feathers have escaped from your pillow."

"As you come home and walk through your front door, you notice a crackling noise as you step, you turn on the light and realise that you have stepped on some new post."

"As you open your bin you notice that the lid has a large crack and needs replaced."

"As you sit down on a bench in the park you notice a white pigeon flap its wings fast and fly away."

"As you walk across your bathroom floor in bare feet you step on something, looking down you notice a hand towel underfoot."

"As you are at a family birthday party, a relative's young child walks over to you with a small toy clenched in his fist."

"As you walk down an alley, you notice that you have stepped on a sunken paving stone."

"As you are sitting beside a small child, they knock over their drink and water spreads across the seat and onto the floor below."

"As you are watching TV you notice something brushing against your ankle, you look down to see your cat running away."

"As you search in your loft for some tools, you disturb a pile of books and they fall and scatter to the floor by the wall."

"As you sit across from someone on a train you notice that they have blue ink on their face from a pen that has leaked."

"As a colleague goes to shake your hand you notice that they have a cluster of golden freckles on two of their fingers."

"As you brush your hair the day after you help out on a school trip, you realise that the sun has lightened it."

"As you sit down to have a haircut, you hear the hairdresser inform another customer that an offer is available."

"As you finish mopping up a spill on your kitchen floor, you accidentally drop a package of new cleaning cloths onto your feet and a few fall out and unfold."

"As you walk outside you accidentally drop your keys onto some grass that is scattered with autumn leaves and have to reach down to get them."

"As you are talking to a friend they unexpectedly start laughing as you speak."

“As you are standing at a bus stop, a stranger loudly starts humming and tapping one of his feet against the ground."

"As you go into your living room one morning, you find that the sofa is covered with cushions."

"As you put your foot in your shoe, you notice that the laces need to be replaced."

"As you walk barefoot along a sandy beach, you accidentally step on a small pebble."

"As you pick up some coins you dropped in the street, you accidentally pick up a used receipt."

"As you wrap yourself in a towel after getting out of the shower, you realise that the towel has some small loose threads all over it."

"As you look in the mirror whilst washing yourself, you notice that the flannel you are using is dripping."