Stuck on disgust: Investigating disgust's memorability

By

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Summary

People remember disgust better (e.g., more frequently and accurately) than other negative and arousing emotions, like fear (termed *disgust memory enhancement*). However, the existing literature examining disgust memory enhancement focuses on voluntary recall and recognition in a laboratory setting. My thesis aimed to address gaps in the literature by examining whether disgust memory enhancement extends to various forms of episodic memory (particularly those relevant to traumatic experiences and Posttraumatic Stress Disorder; PTSD), across a combination of laboratory and real-world settings.

First, I examined disgust's memorability in the context of *intrusions* (or, involuntary memories) in response to personal traumatic events (Chapter 3) and an analogue trauma (i.e., images; Chapter 4). I found that the extent to which people reported feeling disgust was associated with higher intrusion severity (i.e., intrusion persistence) and problematic intrusion characteristics (e.g., distress) to a comparable extent to feelings of fear (Chapter 3). Disgust reactions uniquely predicted intrusion symptoms (i.e., over-and-above fear). Participants also experienced a similar number of intrusions for disgust images (relative to fear images; Chapter 4), and disgust intrusions became more emotionally intense than fear intrusions over time. My findings emphasise disgust's unique role in trauma-related intrusions and suggest disgust memory enhancement extends to intrusions in some ways (enhanced emotional intensity of these intrusions) but not others (intrusion frequency).

Second, I explored whether disgust memory enhancement extends to more *accurate memory* (Chapter 5). The existing memory recognition literature has found consistently low false memory rates for disgust and fear images, likely due to various methodological limitations. For example, in some of these studies the disgust (and fear) image lures matched the emotion category but not the specific *content* of previously seen (old) images (i.e., the lures were *unrelated*). I addressed this limitation by matching each disgust image lure's

content to an ‘old’ disgust image and did the same for the fear images: these lures were *related*. Participants experienced a similar rate of false memories for disgust and fear when lures were related, and fewer false memories for disgust than fear when lures were unrelated. Thus, disgust is not particularly susceptible to false remembering. Rather, consistent with prior research, participants had enhanced memory *accuracy* (i.e., higher correct recognition rates and better memory sensitivity) for disgust relative to fear.

Finally, I explored memory for *feelings of disgust* (Chapter 6), addressing an overarching limitation of past research, which focuses exclusively on memory for disgust *content* (e.g., stimuli, event details). Whilst participants’ disgust and fear reactions to a recent traumatic event similarly persisted in intensity over time (longitudinally), participants retrospectively remembered more persistent feelings of disgust than fear. Therefore, disgust memory enhancement extends to persistent feelings.

Taken together, my thesis extends a growing body of literature showing disgust is particularly ‘sticky’ in memory. Overall, my findings provide some support for disgust memory enhancement (relative to fear) and in other cases, suggest disgust is comparably memorable to fear. Theoretically, my findings fit with both dimensional and discrete accounts of emotion. Clinically, given disgust’s durability in memory following traumatic events, disgust should not be overlooked in cognitive models, diagnostic tools and treatments for PTSD.

Declaration

I certify that this thesis:

1. does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university
2. and the research within will not be submitted for any other future degree or diploma without the permission of Flinders University; and
3. to the best of my knowledge and belief, does not contain any material previously published or written by another person except where due reference is made in the text.

Signed: Lucy Ann Matson

Date: 04/07/2024

Acknowledgement of Country

I would like to acknowledge that this body of work was produced on the lands of the Kaurna nation. I recognise the Traditional Custodians of the land where my research was conducted and pay my respects to their Elders past, present, and emerging. I recognise and respect their enduring connection to the land, waters, and culture, and I am grateful for the opportunity to work and study on this land.

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Chapter 1: Literature Review

1.1 Emotionally Enhanced Memory

“An impression may be so exciting emotionally as almost to leave a scar upon the cerebral tissues” (James, 1890, p. 670). When a person experiences a major life event—such as their university graduation, their wedding day, the birth of their child, the death of a close loved one, or a life-threatening accident—they are likely to experience an intense emotional response. Remembering past emotional experiences is important in all facets of life—these memories shape how we view the world, how we relate to others, and how we make decisions. Indeed, the most consequential events in our life (i.e., the experiences that form our identity) are usually emotional in nature. It is unsurprising, then, that theorists across centuries and researchers across decades have consistently concluded our memory is better for emotional relative to non-emotional (i.e., neutral) experiences (Cahill & McGaugh, 1995; James, 1890; Levine & Pizarro, 2004).

The phenomenon of ‘emotionally enhanced memory’ has even reached popular culture and the general public. Consider the 2015 Pixar film *Inside Out*: five emotions depicted as characters (joy, sadness, fear, disgust and anger) operate in a control room-like setting in young Riley’s head, guiding her decisions in day-to-day life. When Riley experiences a highly emotional reaction to an event (e.g., when her parents comforted her after she ran away from home), a ‘core memory’ is created and stored in a separate section of the memory system in her brain. These ‘core memories’ are formative to Riley’s identity, personality, and ability to live a meaningful life. The film’s notion of ‘core memories’ being stored in a separate section of our memory system is not a true reflection of how memory works. Rather, ‘core memories’ reflect how these highly emotional events are more *accessible* in our memory system and therefore, better remembered than other, less emotional events.

What does *better* memory actually mean for emotionally enhanced memory? Research suggests memories for emotional events are more frequent, vivid, and long-lasting than memories for neutral events (e.g., Cahill & McGaugh, 1995; Reisberg, 2006). This emotionally enhanced memory effect exists for both voluntary (i.e., deliberately retrieved) and involuntary (i.e., spontaneous memories occurring without any deliberate attempts of retrieval) autobiographical memories (Berntsen, 2010). Furthermore, emotionally enhanced memory occurs in both laboratory studies (e.g., using emotional *pictures*, Bradley et al., 1992; *films*, Ferree & Cahill, 2009; *words*, Kensinger & Corkin, 2003; and *stories*, Burke et al., 1992) and naturalistic studies (e.g., asking participants about past *personal emotional events*; Berntsen, 2001).

In one laboratory example, Cahill and McGaugh (1995) presented the same slideshow of photos (depicting a series of events at a hospital) to all participants, either accompanied by a neutral narrative (staff conducting a ‘practice disaster drill’ on an actor purposely made up to appear injured) or an emotional narrative (staff fighting to save a young boy’s life after a motor vehicle accident). Following a two-week delay, participants exposed to the emotional narrative recalled more photos from the slideshow, and correctly recognised (from multiple choice questions) more details pertaining to the narrative, relative to participants exposed to the neutral narrative. Turning to a naturalistic example, people typically subjectively experience extremely vivid and long-lasting ‘flashbulb memories’ (Brown & Kulik, 1977) of the circumstances they were in when receiving news of emotional events deemed personally significant (e.g., receiving an invitation to join a university-wide social organisation; Kraha & Boals, 2014) and/or globally shocking (e.g., Princess Diana’s death, Hornstein et al., 2003; September 11 attacks, Conway et al., 2009). Thus, memory for emotional—relative to neutral—stimuli/experiences is considered *better* because emotionally enhanced memory has been broadly observed across various forms of stimuli or lived experiences, and through various forms of measurement (e.g., memory recall, memory recognition and memory characteristics such as vividness).

There is some evidence that emotional memories are more *accurate* than neutral memories (Christianson & Loftus, 1991; Levine & Pizarro, 2006; Reisberg, 2006). Due to the vivid, detailed and long-lasting nature of emotional memories, people report an intense subjective sense of remembering emotional events—and more confidence in the accuracy of these memories—compared to a more general sense of familiarity when remembering neutral events (Mihaylova et al., 2019; Dolcos et al., 2006). In other words, people are more inclined to vividly remember contextual details of emotional events (e.g., what they were doing immediately before the event occurred). Whereas for neutral events, people are more inclined to feel a sense of vague familiarity (i.e., they know the event likely occurred but are unable to retrieve specific details of the event in their memory).

However, despite earlier propositions that memory for highly emotional experiences may be indelible (Le Doux, 1992), or retained with close to photographic accuracy (Brown & Kulik, 1977), emotional memories (like non-emotional memories) are still prone to errors, forgetting, bias, inaccuracy and incompleteness (Berntsen, 2001; Laney & Loftus, 2008; Levine et al., 2009). The source monitoring framework—which refers to discriminating the origins of information within a memory (e.g., the event itself, voluntary or involuntary thoughts about the event, statements made by others about the event)—illustrates how emotional events may be inaccurately remembered (Johnson et al., 1993). For example, in the context of eyewitness testimony, people are prone to source monitoring errors when recounting the sequential events of a crime. Indeed, their memory of this emotional event is often distorted by other relevant information (e.g., intrusive memories or mental elaborations of the event, information shared by other witnesses and/or suggestive interviewing techniques used by law enforcement), which impairs their ability to accurately discriminate whether they had directly or indirectly experienced aspects of the event that they had brought to mind (Lindsay, 1994; Strange & Takarangi, 2015). Thus, whilst emotional memories are vivid and frequently retrieved (intentionally or unintentionally), these memories are not always accurate. In fact, increased rehearsal of these memories (through discussion and/or subsequent involuntary memories) could pose a risk for memory errors.

Mechanisms of Emotionally Enhanced Memory

There are many proposed psychological mechanisms driving emotionally enhanced memory, but three are robustly supported in the literature: attention, rehearsal, and distinctiveness. First, people pay more attention to emotional—relative to neutral—events (because these events are more novel and personally important; Carretié, 2014). Greater attention typically leads to more time spent processing a situation or stimulus, which allows for better encoding and subsequent memory retrieval (Hamann, 2009; Talmi et al., 2007b). Second, because emotional events are personally important, we tend to rehearse these events both internally (e.g., mull over the event in the minutes/hours/days following its occurrence and consider how the experience may relate to past experiences or future consequences) and socially (e.g., discuss the experience with other people; Reisberg, 2006). This rehearsal allows for both better consolidation of the emotional experience into long-term memory as well as increased memory connections, where the memory has more opportunity to be retrieved from an increased number of cues (Berntsen, 2001; Levine & Pizarro, 2004). For example, following a car accident, a person may discuss their experience with others, elaborating on details of the event (e.g., the model of car they were hit by, the types of first responders they were met by). Elaborating on these details increases a person's memory connections and thus, increases the likelihood that certain environmental cues (e.g., hearing ambulance sirens and seeing similar cars to which they were hit by) may trigger subsequent memories of the event. Notably though, this sharing and rehearsal of emotional experiences may also increase source monitoring errors (e.g., confusing the actual experience with someone else's interpretation of the experience), which provides some explanation for why emotional memories are not always accurate (Reisberg, 2006; Paterson et al., 2011). Finally, consistent with theories of forgetting based on cue interference (i.e., a cue is more likely to elicit memory retrieval if it is uniquely associated with the target), emotional experiences are more distinctive and unusual relative to neutral experiences (Berntsen & Hall, 2004; Staugaard & Berntsen, 2014). Therefore, because people are more frequently exposed to neutral experiences, there is less opportunity for environmental cues to be unique enough to trigger memories for these experiences. For example, a person is unlikely to remember details pertaining to a certain grocery store visit due to frequent grocery store visits that are similar in nature.

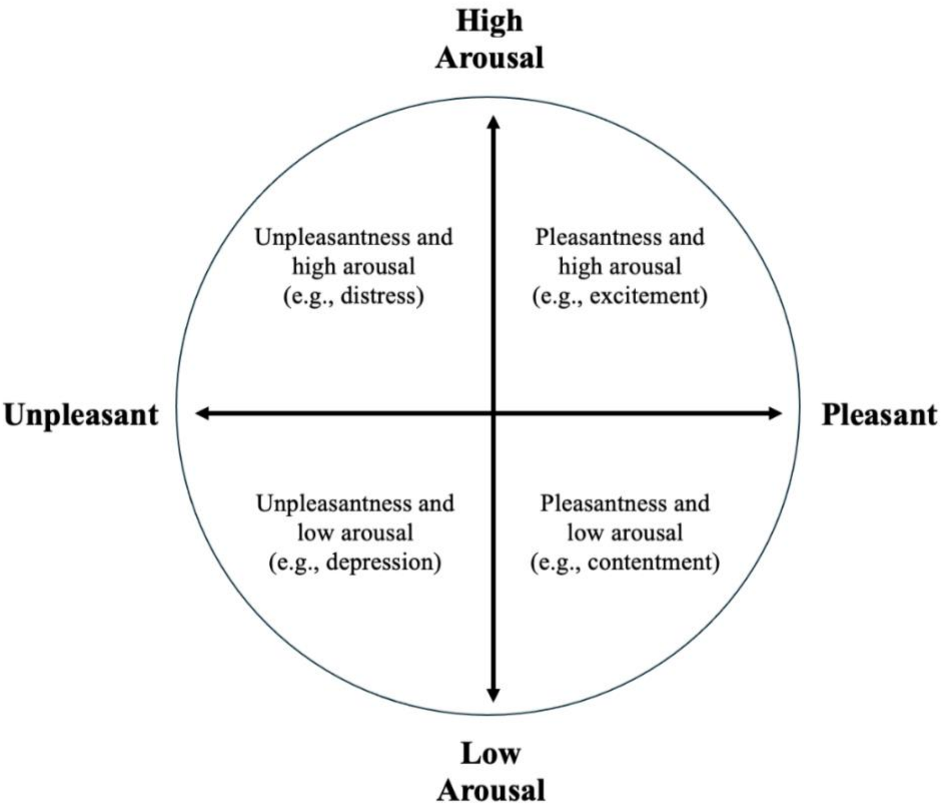
To summarise, several decades of research confirm that emotional experiences are more memorable than neutral experiences, and this bias occurs partly because emotional experiences are more personally important, attention-grabbing, rehearsed, and distinctive than neutral experiences. But what *is* an emotion? William James first posed this question in 1884. Since then, scholars have proposed and debated many theories (e.g., Adolphs et al., 2019), without agreeing on a clear-cut answer. I will next elaborate on two key conceptualisations of emotion in the context of emotionally enhanced memory: dimensional accounts (e.g., Russell, 1980) and discrete accounts (e.g., Ekman, 1992). Although there are several dimensional accounts of emotion (e.g., approach and withdrawal; Lang et al., 1998), here I consider Russell's (1980) circumplex model of affect, which comprises arousal and valence dimensions. I also elaborate on *appraisal theories* of emotion, which propose that emotions are *processes* rather than states, influenced by how we appraise events based on factors such as our goals and motivation (Moors et al., 2013). Whilst a separate conceptualisation of emotion, appraisal theories have some overlap with both dimensional and discrete accounts of emotion (i.e., appraisals have been studied as dimensions [goal congruency – goal incongruency] and as predictors of basic emotions; Roseman, 1991; Scherer et al., 2006). Thus, here I discuss appraisal theories in the context of dimensional and discrete accounts of emotion. I view dimensional and discrete perspectives of emotion as not mutually exclusive. Rather, I consider both conceptualisations as crucial to understanding the relationship between emotion and memory.

1.2 Dimensional Accounts of Emotion

Early research on emotionally enhanced memory focused on ‘emotionally arousing events’ (Cahill & McGaugh, 1995; Levine & Pizarro, 2006). This focus on ‘emotional arousal’ reflects dimensional accounts of emotion, which suggest two independent bipolar dimensions—arousal (also referred to as ‘activation’; a continuum that varies from calm to excitement/alertness) and valence (a continuum that varies from pleasant to unpleasant, with neutral as the middle-point; See Figure 1.1)—are both necessary and sufficient for defining an emotional experience (Faith & Thayer, 2001; Lang et al., 1993; Russell, 1980).

Figure 1.1

Arousal and Valence Continuum Quadrants in Dimensional Accounts of Emotion With Example Affective States



Note. Example affective states are taken from Russell's (1980) circumplex model of affect (p. 1164).

To identify the dimensions fundamental to emotional experiences, Russell (1980) asked participants to sort 28 words used to describe *moods, feelings, temporary states, affect, or emotions* (e.g., happy, alarmed, sleepy) into categories based on perceived similarity. A multidimensional scaling analysis revealed each word could be placed somewhere within the arousal and valence continuum quadrants (e.g., 'alarmed' is highly arousing and moderately-to-highly unpleasant; 'happy' is moderately arousing and highly pleasant). Similarly, Faith and Thayer (2001) asked participants to rate the extent to which they experienced 15 emotions (e.g., disgust, interested) in response to various emotional stimuli (music, images, imaginal scenarios, facial expressions). A factor analysis revealed two clear, interpretable factors: arousal and valence, and these factors accounted for 51% of the variance in the model. Lang et al. (1993) further demonstrated certain physiological responses relate to these two dimensions, with smiling/frowning muscles loading on the 'valence' factor and skin conductance loading on the 'arousal' factor. Overall, advocates for the dimensional account of emotion argue that all emotions are a unique combination of valence and arousal levels, and we interpret these emotions from our internal state (e.g., biological responses) rather than through psychological mechanisms (e.g., appraisals of an experience; Faith & Thayer, 2001; Lang et al., 1993; Russell, 1980). Below I will discuss how each of these dimensions of emotion relate to memory.

Arousal

Arousal is undoubtedly a mechanism for emotional memory enhancement (both for pleasant and unpleasant stimuli), evidenced by research measuring brain activation in the amygdala (Canli et al., 2000; Dolcos et al., 2006; Hamann et al., 1999). The amygdala is an emotional-processing system in the brain that is closely connected to—and when activated, enhances activity in—other brain regions associated with encoding and consolidation processes (e.g., the hippocampus; Kensinger & Corkin, 2004; McGaugh et al., 1996). When a person perceives emotional stimuli as highly arousing, stronger amygdala activation occurs (Weymar & Schwabe, 2016). Furthermore, increasing amygdala activation (i.e., through infusing epinephrine, a stress hormone commonly known as 'adrenaline') when viewing emotional stimuli increases subsequent memory recall and accuracy, and inactivating the amygdala (i.e., through brain lesions or drug administration) reduces emotional memory enhancement (Adolphs et al., 1997; Levine & Pizarro, 2006; McGaugh, 2000). However, whilst biological arousal is a *necessary* component of emotion and emotionally enhanced memory, it is not *sufficient* in explaining how emotion influences memory (Levine & Pizarro, 2004; Reisberg, 2006). Indeed, exercise-induced arousal (e.g., by running or cycling) does not enhance memory for emotional or neutral stimuli (Libkuman et al., 1999). Further, memory for emotional events differs depending on whether the event is associated with positive or negative feelings (i.e., valence; Levine et al., 2009; Walker & Skowronski, 2009), which I elaborate on in the next section. Therefore, there is more to emotion's impact on memory than arousal alone.

Valence

Memory for highly pleasant (positive) and unpleasant (negative) experiences are similar in many respects: these memories are enhanced relative to neutral experiences, they are vivid, personally important, and usually elicit a physical reaction during retrieval (e.g., smiling, blushing; Berntsen, 2001). However, research shows that valence—i.e., whether an event is positive or negative—has different memory effects (Levine & Pizarro, 2006; Schwarz & Clore, 1983). When remembering past emotions and reflecting on current emotions associated with an event, the intensity of positive affect (i.e., emotion and/or mood) tends to persist in memory longer—or, fade in intensity at a slower rate—than the intensity of negative affect, termed the *fading affect bias* (Skowronski et al., 2014). Walker and Skowronski (2009) describe this perseverance of positive affect—and reduction in negative affect—in memory as an *adaptive reappraisal*, whereby the fading affect bias functions to promote a person's positive view of the self, others, and the world around them. Consistently, this memory bias generally occurs among 'psychologically healthy' people. Comparatively, among people with mental health conditions such as depression and Posttraumatic Stress Disorder (PTSD), the intensity of negative affect associated with an event intensity persists in memory similarly to—if not longer than—the intensity of positive affect associated with an event (Bond et al., 2022; Marsh et al., 2019). Therefore, among these clinical populations, people's memory for negative emotions is less inclined to fade over time.

Appraisal theories of emotion also highlight how positive and negative emotions are differentially processed and remembered (Levine & Pizarro, 2006; Schwarz & Clore, 1983). Specifically, people experience positive emotion when goals have been met and circumstances are favourable and thus, there are no immediate problems to be solved (Levine & Pizarro, 2004). Therefore, when recalling memories, people typically perceive minimal risk in problems arising as a result of inaccurate recall and thus, flexibly draw on general knowledge/stereotypes ('top-down information processing strategy') during retrieval. For example, participants induced into a positive mood before hearing a story about going to out to dinner at a restaurant reported remembering more information from the story that was consistent with their general knowledge (e.g., "the hostess placed menus on the table") than participants who had been induced into a sad mood, independent of whether that information had actually been portrayed in the story or not (Bless et al., 1996).

In contrast, negative emotions often occur in response to threatened, obstructed or failed goals where there is a problem to solve (Levine & Pizarro, 2004). Therefore, when recalling memories involving negative emotion, people carefully, effortfully and systematically process information so as to repair past and/or avoid future negative outcomes ('bottom-up information processing strategy'). Consistently, research suggests people use a conservative threshold when recalling details relating to negative events and/or when in a negative mood (Bless et al., 1996; Levine & Bluck, 2004; Park & Banaji, 2000). For example, when tested on details about the televised announcement of O.J. Simpson's murder trial one year after it occurred, participants who reacted negatively to the verdict reported remembering fewer details overall (regardless of accuracy) compared to those who reacted positively (Levine & Bluck, 2004). In contrast, these studies show people use a more liberal threshold when remembering information related to positive emotions, where they report more accurate *and* inaccurate details of positive experiences (i.e., tend to confuse plausible or imagined events with real events; Kensinger et al., 2007). Regardless of these thresholds—or, response biases—people's memory for negative experiences is similarly (e.g., Berntsen, 2002)—if not more (e.g., Bohn & Berntsen, 2007)—accurate compared to their memory for positive experiences.

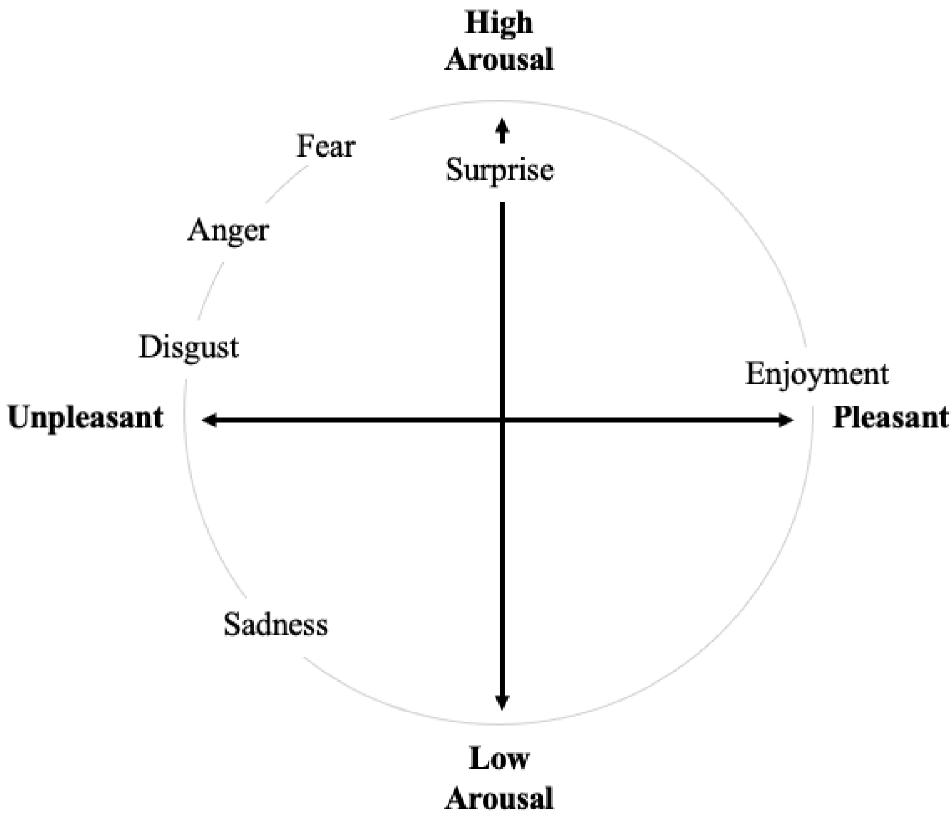
Taken together, then, dimensional accounts of emotion—and the associated research examining enhanced memory for arousing and negative/positive experiences (relative to neutral, non-arousing experiences; Berntsen, 2001; Cahill & McGaugh, 1995) and memory differences for experiences on either end of the valence dimension (i.e., positive or negative)—underscore how arousal and valence are necessary components of emotion and emotionally enhanced memory. However, returning to Faith and Thayer's (2001) factor analysis, arousal and valence accounted for 51% of the variance in their model defining emotional experiences, suggesting 49% of this variance was not accounted for. Therefore, there is more to emotion than arousal and valence alone. Whilst there are many other missing pieces to the puzzle that are beyond the scope of my thesis, I will next focus on discrete accounts of emotion. Compared to arousal and valence, less is known about how discrete emotions (e.g., disgust, fear) differentially influence memory.

1.3 Discrete Accounts of Emotion

Discrete accounts of emotion acknowledge the diversity in how people experience and express different emotions (Levine & Pizarro, 2006; Oatley & Johnson-Laid, 2014; Ortony, 2021). Early conceptualisations of discrete emotions—which are still highly influential in research and undergraduate psychology course materials today—focus on a select few *basic emotions* (e.g., Ekman, 1992; Izard, 2011). Basic emotion theories were largely guided by Darwin's (1965/1872) evolutionary approach, which categorises emotions as signals for basic survival (e.g., *fear* protects us from imminent danger, *disgust* protects us from contamination). Ekman (1992) provides arguably the most influential account of the 'basic six' emotions: anger, fear, enjoyment, sadness, disgust and surprise (though, Ekman's theory is continuously evolving, and currently includes up to 20 basic emotions; Ekman & Cordaro, 2011). Figure 1.2 shows how the basic six emotions map onto the arousal and valence continuum quadrants in dimensional accounts of emotion. Ekman theorises that basic emotions evolved so that people (and other primates) can adaptively deal with fundamental life tasks based on their past adaptive behaviour both in an evolutionary-sense (e.g., we know rotten food should be rejected, or expelled if swallowed) and their own lives (e.g., a child learns to seek out their caregiver for safety and soothing when scared). Ekman and Cordaro (2011) propose 13 criteria that an emotion must meet to be considered 'basic'; the most important—and widely agreed upon—criteria are: distinctive and universally recognised facial expression, unique physiological signature, presence in other animals, brief duration (i.e., seconds/minutes), and innateness (i.e., rapid onset). Ekman and Cordaro also propose that all non-basic emotions lie within an "emotion family" of states related to a basic emotion (e.g., irritation and rage belong to the 'anger' family). However, beyond considering emotions as evolutionarily important, basic emotion theorists disagree (e.g., Izard, 2011; Oatley & Johnson-Laird, 2014)—including within Ekman's own theory over time—about which emotions are basic, and what criteria an emotion must satisfy to be considered 'basic'. Though, as Ortony (2021) argues, the more important questions to be answered are how different emotions may differentially influence cognitive processes such as appraisals, decision making, attention, and memory.

Figure 1.2

The 'Basic Six' Emotions Overlayed on the Arousal and Valence Continuum Quadrants (Adapted From Widen & Russell, 2008)



A broader focus on discrete emotions rather than select 'basic' emotions allows us to shift our focus towards these more important questions. Returning to appraisal theories of emotion; appraisal theories posit that different emotions lead people to differentially evaluate which information is functional, important and goal-relevant, and thus ultimately, which information they should focus their attention towards (Levine & Pizarro, 2006). For example, when frightened, people selectively attend to, encode and retrieve threat-related information (and have poorer memory for threat-irrelevant information; Christianson & Engelberg, 2006; Levine & Pizarro, 2004; Wessel & Merckelbach, 1998).

Fear is undoubtedly the discrete emotion that has received the most attention in cognitive and clinical psychology research. For example, 'weapon focus' in the eyewitness memory literature refers to witnesses' tendency to focus their attention towards—and accurately remember—the weapon present during a crime (which is known to elicit an intense fear response), typically at the expense of remembering other details of the crime (e.g., the perpetrator's face; Kramer et al., 1990; Loftus et al., 1987; Pickel, 2009). Notably though, little research exists on the links between other discrete emotions and memory, which, as Levine and Pizarro (2004) appropriately emphasise, "leaves us with, at best, an incomplete picture of the relationship between emotion and memory, and at worst, an inaccurate one" (p. 531). My thesis focuses on an overlooked, but similarly arousing and unpleasant emotion to fear: *disgust*.

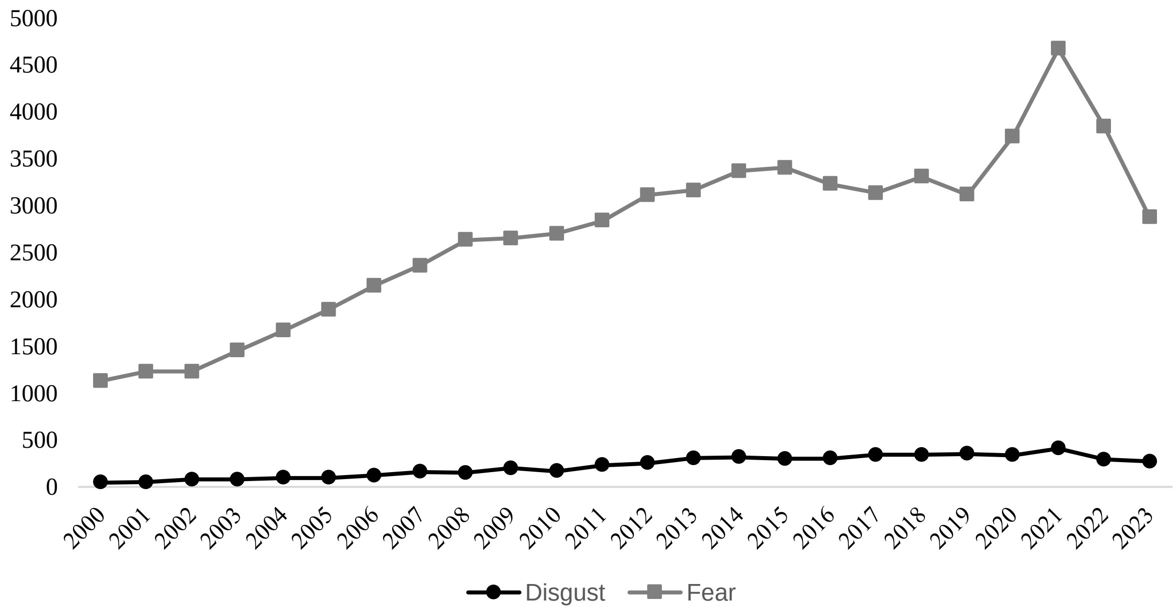
Disgust and Fear: Key Similarities and Differences

Disgust and fear have many similarities; they are both unpleasant and arousing emotions that evolved as warning systems in response to environmental threats (Chapman, 2018; Stark et al., 2004). Fear is characterised by danger-related threats regarding the intactness of the body (e.g., in response to a predator) whereas disgust is characterised by disease-related threats that are more variable in nature (i.e., ranging from pathogens to moral violations; Öhman, 2008, Rozin et al., 2000). Both disgust and fear elicit an avoidance response, but this avoidance response is actioned differently (Olatunji & Sawchuk, 2005). Fear's avoidance properties are active, involving *escape* whereby a person imminently moves away from the stimulus. Comparatively, disgust's avoidance properties are passive, involving *rejection* whereby a person can distance themselves from the stimulus without physically moving away (e.g., observing without contacting the stimulus, gaze aversion, closing eyes).

Despite both emotions' fundamental survival value, disgust has been long overshadowed by fear in empirical research (McNally, 2002; Rozin et al., 2009). Indeed, when Olatunji and Sawchuk (2005) searched (using PsycInfo) for published articles with the keywords 'disgust' and 'fear' across 40 years (1960 – 2003), they found that until the 1990s, there were few published articles with the word ‘disgust’. In the early 1990s, there were approximately 20 – 25 articles published annually with the word ‘disgust’, relative to approximately 750 articles published annually with the word ‘fear’. In 2000, published papers referencing ‘disgust’ peaked at 45, in comparison to a staggering 1130 published papers referencing ‘fear’. I extended Olatunji and Sawchuk’s search to include the 21st Century thus far (Figure 1.3[1]). Whilst empirical interest in disgust is increasing, the staggering difference between disgust and fear remains.

Figure 1.3

Psycinfo Literature Search of Published Articles on ‘Fear’ and ‘Disgust From 2000 Through 2023



Perhaps disgust’s aversive properties are so powerful that even studying the emotion is avoided (Rozin et al., 2009). Whilst fear is undoubtedly an important emotion in the context of cognitive and clinical psychology, I—along with other researchers in the field

[1] The number of published articles on ‘fear’ significantly increased in 2020, peaked in 2021, and decreased in 2022. This trajectory coincides with the onset of the COVID-19 pandemic in 2020 (where we observed pandemic-related stress, fear, and uncertainty on a global scale; Bridgland et al., 2021) and the easing of public restrictions (and likely resulting decrease in stress, fear and uncertainty) from 2022 onwards.

(Badour & Feldner, 2018; Chapman & Anderson, 2012; Curtis, 2011; Knowles et al., 2019; McNally, 2002; Olatunji & Sawchuk, 2005; Rozin & Fallon, 1987)—propose that disgust is also important. But to understand disgust's cognitive and clinical relevance, it is important to first unpack disgust in more detail.

1.4 Disgust

Disgust is a complex and durable negative emotion, whereby even the thought of contact with infectious substances (e.g., saliva, faeces) or immoral people (e.g., murderers, paedophiles) elicits a revulsion response (Curtis, 2011; Davey, 2011; Rozin & Fallon, 1987). Darwin (1965/1872) defined disgust as a response to "something revolting, primarily in relation to the sense of taste, as actually perceived or vividly imagined; and secondarily to anything which causes a similar feeling, through the sense of smell, touch and even of eyesight" (p. 253). Darwin's emphasis on *taste* relates to disgust's adaptive function to protect an organism from ingesting potentially contaminating substances, which ultimately reduces the likelihood of illness and disease (Olatunji & Sawchuk, 2005). Indeed, disgust's primary physiological manifestation of nausea signals the organism to orally expel an ingested harmful substance (Davey, 2011; Stevenson et al., 2019). Furthermore, other sensory properties (e.g., rotten smell) may signal potential contamination-related threat, thereby prompting avoidance before touching or eating the substance (Rozin & Fallon, 1987). However, as humans have evolved, disgust elicitors have evolved beyond merely protecting our physical bodies from contamination to other threatening entities, including social and moral threats (Rozin et al., 2000). Therefore, a more inclusive definition of disgust refers to any violation that prompts a rejection response.

Rozin and colleagues' (2000) well-known disgust classification system categorises the emotion into four types: core, animal-reminder, interpersonal, and moral. Table 1.1 (adapted from Chapman & Anderson, 2012) provides example elicitors for each disgust-type.

Table 1.1

Disgust Types With Example Stimulus Triggers and Their Hypothesised Avoidance Function

Type	Example stimulus triggers	Hypothesised avoidance function
Physical Disgust		
Core	Rotten food, body products (e.g., faeces), animals associated with waste (e.g., maggots)	Avoid infection via oral route
Animal-Reminder	Reminders of our animalistic origins	Avoid mortality cues
Blood-Injury	Injuries, blood, bodily deformities	Avoid infection
Sexual	Sexual contact with relatives, very old, very young, different animal species	Avoid compromising reproductive fitness
Interpersonal	Contact with outgroups, unhygienic, unfamiliar, or ill people	Avoid infection
Moral Disgust	Social and moral norm violations (e.g., murder, exploitation, discrimination, theft)	Avoid unsuitable interaction partners

Note. Adapted from Chapman & Anderson (2012)

Core disgust (also termed ‘pure’ or ‘simple’ disgust; Stevenson et al., 2019) refers to stimuli that provoke a real or perceived threat of oral consumption, are evaluated by the perceiver as a contaminant, and produce revulsion and avoidance responses. Core disgust elicitors are most directly shaped by the evolutionary function to avoid pathogens, and produce an automatic, innate neurobiological and physiological reaction (e.g., nausea; Rozin et al., 2009).

Animal-reminder disgust refers to stimuli that remind us of our inherent animalistic nature and hence, our mortality. Animal-reminder disgust can be further separated into two sub-types: *blood-injury disgust*—which refers to bodily excrements and envelope violations (here, human skin is akin to “envelope”) whereby our internal biological features are indistinguishable from other animals' when exposed—and *sexual disgust*—whereby we avoid sexual contact with undesirable partners, such as relatives (Chapman & Anderson, 2012). The overall function of animal-reminder disgust is to maintain the hierarchical division between humans and animals (Curtis, 2011).

Interpersonal disgust refers to aversion towards contact with unfamiliar, unhygienic, or sick people. These aversive reactions towards other people can be motivated by threats of disease acquisition, but also by indirect reminders of our predisposition to illness and death (Olatunji & Sawchuk, 2005). According to Chapman and Anderson (2012), these first three disgust-types (core, animal-reminder, interpersonal) are elicited by concrete sensory properties (e.g., a person interprets a cockroach as disgusting just by looking at it) and can be collapsed into a single category termed 'physical disgust' for interpretation ease.

The final disgust-type Rozin and colleagues (2000) identified—*moral disgust*—is abstract and more contextually dependent than physical disgust (e.g., feeling indifferent towards a person but then feeling disgust towards them upon discovering they are a murderer; Chapman & Anderson, 2012). Moral disgust occurs exclusively in humans, in response to violations of social norms. Moral disgust functions to protect social order, maintain social acceptance and avoid interactions with immoral and unlawful people. People can experience this disgust-type in response to both moral transgressions that encompass physical disgust elements (e.g., rape, torture, murder) and moral transgressions that do not (e.g., lying, theft, bullying; Curtis, 2011). Indeed, moral violations related to fairness (in an economical game where $10 is unevenly split between the participant and a confederate) elicit feelings of disgust, and—when compared to anger and sadness—these feelings of disgust most strongly predict people's decisions to reject unfair offers (from confederate and a computer program; Chapman et al., 2009). These moral violations also elicit feelings of disgust in elementary school-aged children (who affirmed the word 'disgusting' and an image of the disgust facial expression fit with immoral behaviours like stealing and telling lies; Danovitch & Bloom, 2009). Disgust's expansion from pathogen avoidance to an abstract moral domain represents *exaptation*, whereby disgust's pre-existing evolutionary system has acquired new, additional functional roles (Chapman & Anderson, 2012).

Disgust is arguably one of the most culturally diverse emotions (Elwood & Olatunji, 2009). Physical disgust elicitors encompassing body products (e.g., faeces), rotten food and gore are considered universal across cultures (Curtis & Biran, 2001; Rozin & Fallon, 1987). In contrast, insects and spiders are deemed as disgusting and potential disease transmitters in Western cultures, but commonly eaten in other areas of the world (i.e., South and Central America, Asia, Africa; Elwood & Olatunji, 2009; La Barbera et al., 2018). Culture also primarily shapes what is deemed as disgusting in the *moral* domain. For example, collectivist cultures (e.g., Japanese) primarily report moral disgust in response to unpleasant social interactions (e.g., interacting with rude people) whereas individualist cultures (e.g., American) primarily report moral disgust in response to people who violate the basic dignity and human rights of others (e.g., murderers; Elwood & Olatunji, 2009; Haidt et al., 1997). Considerable within-cultural differences also exist in relation to what a person deems disgusting because in several ways, disgust is a socially learned emotion (Olatunji & Sawchuk, 2005). Indeed, only the most primitive disgust reactions (i.e., taste and smell aversions) are observed in infants, whereas disgust towards other elicitors (e.g., faeces and broader hygiene issues during toilet training, sociomoral issues during later development) are taught and modelled to children by their caregivers and close community (Chapman & Anderson, 2012; Sawchuk, 2009; Stevenson et al., 2019). Thus, cultural influences, social modelling, and personal past experiences are key to shaping a person's repertoire of disgust elicitors.

Regardless of whether disgust is elicited by physical or moral stimuli, feelings of disgust are associated with certain physiological manifestations (Elwood & Olatunji, 2009). Physiological manifestations associated with disgust responses include nausea, vomiting, increased salivation, and activation of the parasympathetic nervous system (e.g., heart rate deceleration, though people may experience heart rate acceleration when feeling *moral* disgust; Angyal, 1941; Gilchrist et al., 2016; Levenson, 1992; Olatunji et al., 2012; Ottaviani et al., 2013; Rozin & Fallon, 1987). An extensively researched physiological manifestation is the facial expression that often accompanies feelings of disgust, which functions to defend unwanted oral incorporation and is characterised by wrinkling the nose (to prevent odour input), gaping mouth (to spit or vomit out ingested substances), and furrowing the eyebrows (to limit exposure to the eye surface; Charash & McKay, 2002; Rozin & Fallon, 1987; Tybur et al., 2018). This facial expression is recognisable in infants, across cultures, in other animal species (e.g., rats, monkeys), and in response to orally disgusting stimuli (a bitter drink), physically disgusting stimuli (mutilation photographs), and morally disgusting stimuli (experiencing unfairness in a game; Chapman & Anderson, 2012; Chapman et al., 2009; Olatunji & Sawchuk, 2005; Vrana, 2009; though see Barrett et al., 2019). These physiological manifestations help us to distinguish feelings of disgust from other negative emotions.

1.5 Disgust and Memory

Disgust appears rather ‘sticky’ in memory; that is, disgust responses seem to be easily acquired and difficult to forget (Knowles et al., 2019; Olatunji et al., 2007b; Sawchuk, 2009). Indeed, disgust stimuli (including words, faces, images, advertisements) are enhanced in memory relative to non-disgusting, negative or neutral stimuli (Chapman et al., 2013; Charash & McKay, 2009; Clayton et al., 2017; Duesenberg et al., 2016; Román et al., 2015; Sawchuk et al., 1999). In one example, among nicotine-deprived smokers, anti-tobacco advertisements with content rated high on disgust were better remembered—and influenced people's rejection behaviours (i.e., reduced cravings and increased intentions to quit smoking) to a greater extent—than anti-tobacco advertisements with content rated low on disgust (Clayton et al., 2017). One explanation for this finding is that enhanced memory for threat-related stimuli (like disgust) is evolutionarily functional, enabling us to avoid similar threatening situations in the future (Levine & Pizarro, 2006; Williams et al., 2009).

In terms of brain activation, disgust—along with other arousing, threat-related emotions, like fear—relates to increased activation in the amygdala, which we know has memory-enhancing properties (Dolcos et al., 2006). Furthermore, disgusting stimuli (e.g., odours, images, films) increases activation in the anterior insula—a brain region involved in *interoception,* which is the awareness of internal bodily cues like nausea—to a greater extent than other negative emotions, like fear and anger (Chapman & Anderson, 2012; Mason & Richardson, 2012). The amygdala and the anterior insula have a reciprocal relationship whereby activation of one brain region increases activation in the other (Anderson et al., 2007). Therefore, it is reasonable to assume that disgust is a particularly memorable emotion, perhaps even more memorable than other negative emotions, like *fear*.

Disgust and fear are both highly arousing, negative, threat-related emotions that provoke avoidance behaviours. Yet, disgust and fear are remembered differently. After viewing disgust and fear stimuli (i.e., images or words), people tend to *recall* more disgust than fear stimuli (Chapman et al., 2013; Chapman, 2018; Charash & McKay; Ferré et al., 2018; Moeck et al., 2021; Schienle et al., 2021; Experiment 3 in West & Mulligan, 2021, but not Experiments 1 and 2). Furthermore, when tested on their memory accuracy for previously seen ('old') vs. not seen ('new') disgust and fear stimuli (i.e., images or words), people correctly *recognise* 'old' disgust stimuli better than 'old' fear stimuli (Chapman et al., 2013; Croucher et al., 2011; Ferré et al., 2018; Marchewka et al., 2016; Schienle et al., 2021). Disgust's enhancement in memory—relative to fear—occurs among children, adults, men and women (Schienle et al., 2021) and over varying delays (memory recall: immediately post-encoding to 45 minutes post-encoding, e.g., Moeck et al., 2021; memory recognition: immediately post-encoding to two weeks post-encoding, e.g., Croucher et al., 2011; Ferré et al., 2018). Furthermore, enhanced memory for disgust—relative to fear—still occurs when images are matched on various memory-enhancing variables, including: valence, arousal, distinctiveness (unusualness/eye-catching characteristics) and organisation (stimulus set interrelatedness) ratings (Chapman, 2018; Chapman et al., 2013; Moeck et al., 2021). Therefore, memory enhancement for disgust appears robust, stable across various populations, and cannot be explained solely by dimensional accounts of emotion (i.e., increased valence and arousal), or by other memory-enhancing characteristics like increased distinctiveness.

Disgust's salience in memory has been partly attributed to the notion that people pay more attention towards disgusting stimuli compared to fearful stimuli (Carretié et al., 2011; Chapman et al., 2013; Chapman, 2018; Cisler et al., 2009; Perone et al., 2020; van Hooff, et al., 2013). Indeed, people display enhanced attention towards disgusting stimuli during incidental encoding tasks where they are shown disgusting, frightening and neutral stimuli whilst simultaneously completing another task (e.g., viewing photographs whilst indicating the location of an adjacent line; Chapman et al., 2013; Chapman, 2018; Moeck et al., 2021). This heightened attention towards disgust relative to fear may be a result of evolutionary survival strategies, where frightening stimuli generally threaten danger and an urgency to flee the situation (e.g., escaping from a predator), so quickly responding to these stimuli is important. On the contrary, there are lower costs in attending to disgusting stimuli, because threats are often subtle and pose no imminent danger (e.g., mould on a piece of bread; Perone et al., 2020). In fact, spending longer attending to disgusting stimuli maximises potential benefits (e.g., being able to consume the bread after realising it is not mouldy; Carretié et al., 2011). This logic fits with the idea that disgusting stimuli may *hold* our attention longer than frightening stimuli (Chapman et al., 2013). Despite disgust's clear attention and memory-enhancing properties, evidence on whether disgust's attentional salience *explains* subsequent enhanced memory for disgust is mixed. The current evidence demonstrates attention can fully account (Chapman, 2018), partially account (Chapman et al., 2013) and not account at all (Moeck et al., 2021) for disgust's memory enhancement, relative to fear. Therefore, further research is required to make robust conclusions regarding whether increased attention toward disgusting stimuli explains enhanced memory for disgusting stimuli.

Memory for disgusting stimuli may also be influenced by differences in how people experience disgust. *Disgust propensity* refers to how easily and frequently people experience disgust and *disgust sensitivity* refers to the degree to which disgust experiences are perceived as negative, unbearable and/or harmful (Olatunji & Cisler, 2009). People with higher disgust propensity levels voluntarily recall more disgust-related words (Charash & McKay, 2002) and report more intrusions (i.e., unwanted, involuntary memories) in response to a disgusting film (Bomyea & Amir, 2010). There is no research to my knowledge that explores the relationship between disgust sensitivity and voluntary or involuntary memory for disgust stimuli. Individual differences in experiencing disgust may influence memory for disgust, such that people with high trait disgust levels may have a low threshold for disgust elicitors (e.g., overestimate contamination probability), and/or experience difficulty diverting attention away from disgusting stimuli and thus, experience frequent and vivid memories about the disgusting stimuli (Bomyea & Amir, 2010; Knowles et al., 2019). Although our ability to learn from and remember disgusting experiences has been adaptive for human survival, disgust proneness (i.e., high trait disgust) and disgust memory biases may adversely impact daily functioning by increasing a person's risk of experiencing—and feeling distressed by—excessive disgust, which may in turn contribute to the development and maintenance of certain mental disorders (Olatunji & Sawchuk, 2005; van Overveld et al., 2011; Williams et al., 2009).

1.6 Disgust and Psychopathology

Fear has long been empirically recognised as a central emotion in the development and maintenance of various psychopathologies, particularly anxiety disorders (Olatunji & Sawchuk, 2005). As disgust has attracted more empirical interest over the past couple of decades, research has also implicated disgust as a relevant emotion in various mental disorders (Davey, 2011; Knowles et al., 2019; Olatunji et al., 2007a; 2007b). The role of disgust in psychopathology has been predominantly examined for three mental disorders: Obsessive Compulsive Disorder (OCD; Olatunji & Sawchuk, 2005), Specific Phobias (particularly animal and blood-injury-injection phobias; Davey & Marzillier, 2009; Page & Tan, 2009), and eating disorders (particularly Anorexia Nervosa and Bulimia Nervosa; Anderson et al., 2021). Higher levels of trait disgust (i.e., disgust propensity and/or sensitivity) are associated with more severe symptomatology among clinical populations with each of these disorders (Ferreira et al., 2021; Olatunji & Sawchuk, 2005; Olatunji et al., 2007a; Troop & Baker, 2009). Indeed, these disorders have clear disgust-eliciting properties—contamination concerns for OCD and phobias, and food rejection and/or self-focused disgust in eating disorders (Davey, 2011).

Disgust's unique involvement in OCD—a mental disorder characterised by obsessions (i.e., intrusive thoughts) and compulsions (i.e., repetitive behaviours or mental acts that reduce distress and neutralise obsessions; American Psychiatric Association [APA], 2022)—is well-supported in the literature (Curtis, 2011; McKay & Moretz, 2009; Olatunji & Sawchuk, 2005). The most common subtype of OCD is contamination concerns, accounting for approximately 55 – 65% of OCD-related concerns (Bhikram et al., 2017; Ruscio et al., 2010). People with contamination-related OCD typically experience intrusive thoughts about contamination, reduce their distress by excessively sanitising and washing, and avoid contact with potentially contaminating objects (Bhikram et al., 2017; Curtis, 2011; Olatunji & Sawchuk, 2005). Disgust and fear typically co-occur in this context, termed *contamination fear,* whereby people are overly *fearful* of involuntary contact with stimuli evaluated as *disgusting* due to a perception that the stimuli possess disease-carrying properties (Brady et al., 2010; McKay & Moretz, 2009). However, not all people with contamination-related OCD feel both disgust and fear; some people describe contaminated objects as 'disgusting' as opposed to 'frightening', and are *not* frightened of harm caused by contamination, but rather engage in compulsions and avoidance behaviours to eliminate feelings of disgust (Bhikram et al., 2017; Melli et al., 2015; Tolin et al., 2004). To specifically delineate between harm-avoidance and disgust-avoidance types of contamination-related OCD, Melli et al. created the *Contamination Fear Core Dimensions Scale*. Further, to recognise differences in emotional responding—among other phenomenological differences—between OCD and other fear-based anxiety disorders, the most recent edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) has moved OCD from the 'Anxiety Disorders' category to a separate category titled 'Obsessive-Compulsive and Related Disorders' (APA, 2022).

Among people diagnosed with OCD—as well as people with high levels of contamination fear more broadly—disgust has been implicated in a cognitive bias termed the 'law of contagion'. The law of contagion refers to the belief that even brief contact with a disgusting stimulus can render a previously neutral stimulus as permanently contaminated (i.e., 'once in contact, always in contact'; Bhikram et al., 2017; Frazer, 1890/1959; Rozin et al., 2009). For example, Tolin et al. (2004) empirically measured the law of contagion among people with OCD, an anxious control group (people with Panic Disorder), and a non-anxious control group. The experimenter touched a clean pencil to a contaminated object in the room (individually identified by each participant; e.g., rubbish bin), then touched a second clean pencil to the first pencil, and so on for a total of 12 pencils (i.e., the final pencil only contacted the 11th pencil). People with OCD perceived a ‘chain of contagion’ whereby they rated the final pencil as 60% contaminated, whereas anxious and non-anxious control participants rated the final pencil—as well as several earlier pencils in the chain—as close to 0% contaminated. In another study measuring contamination-related memory biases, people with OCD had better memory for contaminated vs. not contaminated objects, whereas anxious and non-anxious control groups did not demonstrate this memory bias (Radomsky & Rachman, 1999). Notably though, participants were not asked to rate disgust and/or fear reactions in response to these objects; it is therefore unclear which of these emotions people with OCD had primarily experienced. Taken together, these research findings highlight how people with contamination-related OCD can feel a combination of fear *and* disgust—and under some circumstances, solely disgust—in response to triggers, and how such triggers are particularly memorable.

Another mental disorder that can involve contamination fear is Specific Phobia, which is characterised by “marked *fear or anxiety* about a specific object or situation” in the DSM-5 (APA, 2022). Despite the diagnostic criteria’s fear focus, certain non-predatory animal phobias (i.e., animals that do not pose a serious physical threat to humans, like spiders, rats, cockroaches and worms) and blood-injection-injury phobias (BII; e.g., aversion towards blood, injuries, injections and medical procedures) evoke intense disgust reactions (Curtis, 2011; Davey, 1994; Olatunji & Sawchuk, 2005). Such disgust reactions predict avoidance behaviours among these clinical populations, including people’s refusal to complete tasks relevant to their phobia (e.g., holding a spider, touching a bloody gauze; Koch et al., 2002; Olatunji et al., 2008a; Woody et al., 2005). As is the nature of contamination fear, elevated feelings of disgust and fear likely co-occur among people with certain animal and BII phobias (Koch et al., 2002; Sawchuk et al., 2002). For example, people with spider phobia typically evaluate spiders as dirty and disease vectors, but also perceive their movements as fast, unpredictable, and thus, frightening (Olatunji & Sawchuk, 2005). Research suggests fear is usually the predominant emotional response in spider phobias whereas disgust predominates fear in BII phobias (Koch et al., 2002; Olatunji & Sawchuk, 2005). For example, in two studies where people with spider or BII phobias evaluated phobia-relevant scenes (e.g., images of spiders or surgeries), 74–78% of spider phobics responded as primarily fearful, whereas 78–100% of BII phobics responded as primarily disgusted (Sawchuk et al., 2002; Tolin et al., 1997). Overall, these research findings highlight how among certain phobias, disgust is just as—if not more—important in comparison to fear.

In addition to disgust's role in OCD and specific phobias, disgust is implicated in a range of eating disorders. The two most common eating disorders are Anorexia Nervosa—characterised by significant food restriction and an intense fear of gaining weight—and Bulimia Nervosa—characterised by recurrent binge eating episodes and subsequent compensatory behaviours (e.g., purging/vomiting) to prevent weight gain (APA, 2022; Davey, 2011; Olatunji & Sawchuk, 2005). Disgust can influence Anorexia Nervosa and Bulimia Nervosa in two key ways. First, people with these eating disorders tend to evaluate food—particularly high caloric food—as disgusting and as producing disgust-inducing outcomes, such as nausea, bloating and fullness (Anderson et al., 2021; Bektas et al., 2022). Second, this clinical population has higher levels of self-disgust—where people view themselves as inferior and possessing negative attributes; closely tied to shame—than the general population (Bektas et al., 2022). Specifically, people with eating disorders negatively evaluate their body and physical appearance as disgusting, and their behaviour as disgusting after periods of binge-eating (Davey, 2011; Olatunji & Sawchuk, 2005). Indeed, 'feeling *disgusted* with oneself' is a symptom of Binge-Eating Disorder (similar symptoms to Bulimia Nervosa, without the requirement of compensatory behaviours) in the DSM-5 (APA, 2022).

Taken together, disgust influences the development and maintenance of certain mental disorders, including phobias, OCD and eating disorders. A clinical disorder that has been largely overlooked in relation to its relevance to disgust is Posttraumatic Stress Disorder (PTSD). PTSD—which I will further describe in the section below—shares similar properties to the clinical disorders described above. Like OCD, a key symptom of PTSD is *intrusive* memories (APA, 2022). Like specific phobias, diagnostic manuals have explicitly recognised *fear* as a necessary emotion in PTSD. And finally, people with PTSD may feel disgust towards physical situations, moral situations, and—as in eating disorders—even towards *oneself* (Badour & Adams, 2015). The limited research on the relationship between disgust and PTSD suggests PTSD is also a disgust-relevant disorder (Badour & Feldner, 2018).

1.7 Posttraumatic Stress Disorder

As outlined in the current DSM-5, Posttraumatic Stress Disorder (PTSD) occurs in response to one or more traumatic events involving exposure to actual or threatened death, serious injury or sexual harm (APA, 2022). PTSD is characterised by four key symptom clusters: intrusions (or, re-experiencing; e.g., recurrent and distressing intrusive memories, thoughts, dreams and/or imagery), avoidance of trauma reminders (e.g., memories and situations), alterations in cognition and mood (e.g., persistent negative emotional state and distorted cognitions about the causes and/or consequences of the traumatic event), and hyperarousal and reactivity (e.g., irritability, hypervigilance, concentration difficulties, and recklessness). For a PTSD diagnosis, the symptoms described above must be distressing, cause functional impairment, and manifest for at least one month (as short-lived symptoms may just represent a typical, expected traumatic stress reaction; Ehlers & Clark, 2000). Lifetime prevalence rates of PTSD for adults from the United States sit somewhere between

6.1% – 8.3%[2] (APA, 2022), but are higher in women (13-20%) than men (6-8%; Bryant, 2019). There are lower prevalence rates of PTSD for some traumatic event-types than others (e.g., 5-10% for natural disaster survivors vs. at least 40% for sexual assault survivors; Bryant, 2019).

Traumatic events are memorable because they are highly emotional, arousing, attention-grabbing, personally significant, distinctive from day-to-day experiences, and involve threat (Berntsen, 2001; Christianson & Engelberg, 2006; Dalgleish & Power, 2004; Hayes et al., 2012; Levine et al., 2009). Intrusions—a form of *involuntary* memory—commonly occur following traumatic events, are often vivid in nature, and accompanied by intense emotional reactions (e.g., fear, terror) and physiological reactions (e.g., rapid breathing, nausea; (Berntsen, 2001; Ehlers et al., 2002). The emotional and physiological reactions that accompany intrusions are usually consistent with the emotional and physiological reactions experienced at the time of the trauma (Bower & Sivers, 1998; Resick et al., 2008). These accompanying emotional and physiological—as well as broader sensory (e.g., smells, sounds)—elements to an intrusion may be so intense that it may feel as though the event were recurring in that moment (i.e., a 'flashback'; APA, 2022; Resick et al., 2008). People may also experience intrusive emotions and/or physiological sensations associated with a traumatic event without an accompanying recollection of details of the event (Ehlers & Clark, 2000). Intrusions can be triggered by various situational cues associated with the trauma (e.g., sounds, smells, locations, activities, people, moods, thoughts), though, are often experienced as 'out of the blue' (i.e., these triggers may not be obvious at the time; APA; 2022; Resick et al., 2008).

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[2] Lifetime prevalence rates of PTSD for adults on a global scale (in 24 countries) was 3.9% overall, but varied substantially between countries (APA, 2022; Koenen et al., 2017).

Cognitive accounts of PTSD describe how the disorder develops and is maintained, with a core focus on intrusion symptoms (Bower & Sivers, 1998; Dalgleish & Power, 2004; Ehlers & Clark, 2000; Steil & Ehlers, 2000). These cognitive accounts highlight how PTSD persists when a person experiences a sense of ongoing threat—typically conceptualised as *fear*—after the traumatic event has occurred, as a consequence of distressing intrusive memories and negative appraisals about the trauma. Specifically, a cyclical process occurs whereby a person experiences trauma-related intrusions and as a result, attempts to avoid trauma-related memory cues (e.g., certain people, places) or actively tries to suppress any trauma-related memories, which leads to increased hypervigilance and selective attention towards signs of threat, which ultimately increases the likelihood of future distressing intrusions (Bower & Sivers, 1998; Bryant, 2019; Resick et al., 2008). People with PTSD tend to negatively appraise their traumatic experiences (e.g., “the world is unsafe”) and symptoms, like intrusions (e.g., “I have lost control of my mind”; Ehlers & Clark, 2000), which prevents them from processing the traumatic experience in a holistic way (i.e., by understanding how the traumatic experience has influenced their self-concept and worldview; Steil & Ehlers, 2000). Evident from these cognitive models, PTSD is “a disorder of memory” (McNally, 2006, p. 271), whereby *intrusions* are central in the development and maintenance of broader posttraumatic stress (PTS) symptomatology. Indeed, network analyses measuring the connectedness between PTS symptoms among trauma survivors reveal intrusion symptoms are central to other PTS symptoms (Bryant et al., 2017). Specifically, intrusion symptoms both predict and are predicted by other PTS symptoms, including avoiding trauma-related thoughts, increased arousal/physiological reactions and being upset by trauma-related reminders.

It is relatively normal to experience intrusions following a traumatic event; they are considered a typical part of recovery and processing of a trauma. But the risk of developing

PTSD increases when intrusions are distressing, chronic, debilitating and appraised as dysfunctional (APA, 2022; Marks et al., 2018; McFarlane, 1992; Michael et al., 2005; Schooler et al., 1999; Steil & Ehlers, 2000). Marks et al.'s intrusive retrieval feedback loop (2018) models how 'problematic' intrusion characteristics (i.e., distress, vividness, emotional intensity, 'here-and-now' flashback qualities) maintain intrusion—and other PTS—symptoms. Specifically, intrusions with these characteristics are easily retrieved (and therefore, memorable), reinforce maladaptive processing (e.g., appraising the intrusion as negative, unwanted), and encourage avoidance behaviours (e.g., thought suppression). Thus, consistent with cognitive accounts of PTSD, a cyclical process occurs whereby problematic intrusion characteristics increase the likelihood of future persistent and distressing intrusions, as well as broader PTS symptom clusters.

When a person experiences recurring trauma-related intrusions, they in turn also continuously feel the emotion associated with the trauma memory (Dalgleish & Power, 2004). *Fear* has been long understood as the primary emotion in response to traumatic experiences, to the extent that experiencing "an intense fear, helplessness or horror" response was historically a necessary requirement to receive a PTSD diagnosis (APA, 1994). Traditional learning theories—namely classical and operant conditioning processes—explain how fear develops and is maintained following traumatic experiences (Bower & Sivers, 1998; Resick et al., 2008). During a traumatic event, classical conditioning processes operate whereby a person experiences intense fear and as a result, learns to associate this intense fear response with cues that were present during the trauma (Bryant, 2019). For example, a person who was sexually assaulted in their bedroom may then feel fearful whenever alone in their bedroom. Continuously feeling fearful (e.g., as a result of recurring intrusions) can lead to increased hypervigilance and a low-level elicitation of the emotion, whereby the conditioned fear response generalises to stimuli more remote from the initial conditioned stimulus (Bower

& Sivers, 1998). For example, the person's fear towards being alone in their bedroom may generalise to being alone in any situation. Following a traumatic event, operant conditioning processes—where desirable consequences increase future behaviour and undesirable consequences reduce future behaviour—maintain feelings of fear and represent avoidance symptoms (Resick et al., 2008). Specifically, avoiding trauma cues or memories produces a desirable consequence of short-term fear reduction, but does not allow a person to learn that the feared outcome will not always occur in response to trauma cues and thus, maintains PTS symptoms in the long-term (Bryant, 2019). Notably, these emotional conditioning processes are not limited to fear, and people with PTSD can experience various negative emotions during and following trauma exposure, including disgust, anger, shame and guilt (Friedman et al., 2011; Hathaway et al., 2010; Lee et al., 2001).

The latest diagnostic criteria for PTSD—the DSM-5—have moved away from a sole fear focus with four key changes from the previous 4th edition (APA, 1994; 2022). First, PTSD has moved from an anxiety disorder to a separate category titled "*Trauma- and stressor-related disorders*". Second, an *"intense fear, helplessness or horror"* response to the traumatic event is no longer a requirement. Third, to reflect the broad range of negative emotions that can occur in response to trauma, the DSM-5 added the "*negative alterations in cognition and mood*" symptom cluster with *"persistent negative emotional state (e.g., fear, horror, anger, guilt, or shame)"* included as a specific symptom. These changes are important because recent research suggests some people with trauma exposure history—who would have otherwise met criteria for PTSD—present with an absence of fear reactions (Friedman et al., 2011; Hathaway et al., 2010). Finally, to meet criteria for PTSD in the DSM-4, a person had to experience, witness or be confronted with the traumatic event. However, in the DSM-5, a person can also meet criteria for PTSD by "*learning that the traumatic occurred to a close family member or close friend*" or by "*experiencing repeated* *or extreme exposure to aversive details of the traumatic event*". Therefore, people who are exposed to the aftermath of traumatic experiences—once the imminent threat of danger has surpassed—can also develop PTSD (Bryant, 2019). For example, some occupations (e.g., emergency service responders attending the scene of a fatal motor vehicle accident, police officers investigating child exploitation material, online content moderators) involve repeated exposure to gruesome and nauseating situations that would likely elicit *disgust*, an emotion that is not yet explicitly recognised in PTSD diagnostic criteria.

1.8 Disgust and PTSD

Only in recent years has PTSD been increasingly recognised as a disgust-relevant disorder among researchers (Badour & Feldner, 2018; Jones et al., 2020). Yet, disgust's relevance in PTSD can be traced back to the early 20th Century, where British psychiatrist W. H. R. Rivers described case studies involving harrowing traumatic experiences centred around disgust (Dalgleish & Power, 2004; Rivers, 1920). In one case, a soldier who fought in the First World War was flung into the air due to the nearby explosion of a shell, landing face-first into a deceased soldier's dismembered abdomen. In another case, an emergency service worker completing a welfare check entered a home comprising a heavily decomposed corpse, surrounded by a swarm of flies. In both of these cases, the patients felt nauseous in response to the sight, smell and—for the soldier—taste of the scene, resulting in profuse vomiting responses. Both patients reported intrusion symptoms involving nightmares, flashbacks, and intrusive thoughts, images and memories. Feelings of disgust, nausea and an urge to vomit often accompanied these intrusions. These patients also reported avoiding: trauma-related memories, discussing the experience with others, and even eating certain foods, due to generalised feelings of disgust. Both patients experienced clinically significant impairment in their daily functioning and were diagnosed with PTSD. These case studies highlight how disgust-based PTSD can be as disruptive and disabling as fear-based PTSD.

Disgust has since been implicated in a broad range of traumatic experiences, including war (Bomyea & Allard, 2017), sexual assault (Badour et al., 2013a; Coyle et al., 2014), physical assault (Badour et al., 2012), natural disasters (Fredman et al., 2010), and workplace injuries (Grunert et al., 1992). Both physical disgust (e.g., exposure to death, decay and body products; Jones et al., 2020) and moral disgust (e.g., a soldier killing an unarmed civilian; Litz et al., 2009) can occur in response to traumatic experiences. People can also feel self-focused disgust in response to trauma, particularly when they are victims of interpersonal (e.g., sexual, physical, emotional) abuse and may believe they are undesirable, dirty, and/or possess repulsive qualities (Badour et al., 2013b; Rachman, 2006). In one study, 10% of people with PTSD reported disgust as their primarily experienced emotion to their traumatic event (Power & Fyvie, 2013). Importantly, trauma-related disgust reactions correlate with PTS symptom severity (Badour et al., 2012; Bomyea & Allard, 2017), even after statistically controlling for the effects of trauma-related fear reactions (Badour et al., 2013c). These data highlight disgust's relevance in certain traumatic experiences, and PTSD broadly.

There is limited existing research regarding the relationship between disgust and intrusion symptoms, but preliminary evidence suggests disgust's memorability in voluntary memory may extend to *involuntary* memory (Arnaudova & Hagenaars, 2017; Bomyea & Amir, 2010; Engelhard et al., 2011; Krans et al., 2015). In a laboratory setting, participants experienced intrusions after viewing disgust-eliciting films (i.e., displaying harm and bodily injury, Bomyea & Amir, 2010; displaying vomit, Arnaudova & Hagenaars, 2017). In Arnaudova and Hagenaars' study, people experienced more intrusions of a disgust film displaying vomit than for three other negative films (i.e., displaying physical assault, sexual violence and the scene of a fatal car accident). Whilst these three negative films elicited high levels of disgust in participants, the film displaying vomit elicited the most intense disgust response. In the context of everyday life and using a general population sample, Krans et al. (2015) measured how frequently and intensely people involuntarily experience various emotions. They found more frequent and intense disgust reactions—as well as negative affect, distress and bodily sensations—whilst experiencing involuntary memories correlated with higher levels of general psychological dysfunction. In the context of personal trauma, greater feelings of disgust (within the past week) predicted worse intrusion symptoms (as measured via a self-report PTSD measurement subscale) among sexual assault victims (Coyle et al., 2014). Together these findings demonstrate disgust's memorability extends to intrusions.

Elevated levels of disgust propensity and sensitivity may increase a person's likelihood of experiencing disgust during and/or following a traumatic event. Specifically, people with high disgust propensity may experience increased event-related disgust, which may ultimately increase their risk of *developing* intrusion and PTS symptoms (Jones et al., 2020). In line with this idea, higher disgust propensity correlates with higher feelings of disgust during a traumatic event (Engelhard et al., 2011) and increased intrusive memories of a film displaying traumatic material (Bomyea & Amir, 2010). Bomyea and Amir propose that people with high levels of disgust propensity may find it difficult to divert attention away from disgusting stimuli; deliberate attempts to do so may have paradoxical consequences of increased intrusive thoughts about the disgusting stimuli. Turning to those who perceive disgust situations as harmful, people high in disgust sensitivity may have negative appraisals (e.g., distress) about disgust-eliciting events and associated intrusions, which may ultimately increase their risk of *maintaining* PTS symptoms (Jones et al., 2020). Consistent with this view, higher disgust sensitivity correlates with more severe PTS symptoms (Badour et al., 2013b; Olatunji et al., 2014; Engelhard et al., 2011).

Disgust's role in the development and maintenance of PTSD can also be understood in the context of cognitive models and learning theories. Cognitive models of PTSD propose disgust-related symptomatology may manifest as: feelings of disgust and physiological reactions (e.g., nausea) in response to intrusions and trauma reminders; negative appraisals (e.g., "I have been contaminated by this event"); hypervigilance towards signs of contamination; and avoidance behaviours relating to excessive concern with cleanliness, contamination and problems with eating (Dalgleish & Power, 2004; Jones et al., 2020). Similar to fear conditioning, classical conditioning processes operate for disgust, whereby a person may experience intense disgust during a trauma and as a result, learn to associate this intense disgust response with cues present during the trauma (Jones et al., 2020; Woody & Teachman, 2000). For example, a person who was sexually assaulted may feel disgusted whenever they see—or are reminded of—their perpetrator, which may generalise to feelings of disgust towards any same-gendered person as their perpetrator. Following a traumatic event, operant conditioning processes involving avoidance (e.g., of people, places, thoughts, memories) provide temporary disgust reduction, but maintain the conditioned disgust response in the long term. Notably, disgust responses are also formed via an added layer of classical conditioning—*evaluative conditioning*—where a hedonic value (e.g., like/dislike) towards a disgust stimulus (e.g., body products) is associated with a previously neutral stimulus (Badour & Feldner, 2018; Baeyens et al., 1992; Sawchuk, 2009). For example, due to physical contact with the perpetrator's body products (e.g., saliva and other fluids), a sexual assault victim may then evaluate themselves as permanently disgusting, dirty and/or contaminated. In this situation, the previously neutral stimulus (e.g., the victim themself) does not simply 'signal' the possibility of the disgust-stimulus occurring again, but rather the stimulus *becomes* inherently disgusting (Jones et al., 2020).

These evaluative conditioning processes may explain why disgust reactions may not respond as well as fear reactions to *exposure therapy*, a commonly endorsed therapy for treating PTSD (Olatunji et al., 2007b). Exposure therapy draws on reversing classical and operant conditioning processes, wherein an intense emotion—usually *fear*—at the time of a traumatic event results in a strong association between trauma cues and fear response, which is reinforced via avoidance behaviours (Bryant, 2019). Recovery involves habituation learning (i.e., reduction in a learned emotional response's intensity and frequency), where the person is repeatedly exposed to these trauma cues and avoidance behaviour is eliminated, so the person can learn the feared adverse consequence is unlikely to occur again. People with PTSD show a slower habituation trajectory for disgust relative to fear reactions during exposure therapy (Harned et al., 2015). A similar pattern occurs in OCD (McKay, 2006; Olatunji et al., 2009), contamination aversion (Rouel et al., 2018), and for specific phobias (Olatunji et al., 2007b; Smits et al., 2002). These findings suggest disgust reactions leave a sense of "stickiness" in memory; once a stimulus is labelled as disgusting, its disease and/or violation properties are difficult to change or eliminate.

1.9 Conclusion

In conclusion, the extant literature on disgust, memory and trauma is limited. Disgust is a negative and arousing emotion and therefore, consistent with dimensional accounts of emotion (e.g., Russell, 1980), disgust experiences are more memorable than neutral experiences (e.g., Charash & McKay, 2009; Duesenberg et al., 2016; Schienle et al., 2021). However, dimensional accounts of emotion cannot solely explain disgust's memorability because even when matched on arousal and valence dimensions, disgusting stimuli are better remembered than *fearful* stimuli (Chapman, 2018; Chapman et al., 2013; Moeck et al., 2021). Therefore, consistent with a discrete emotional perspective (e.g., Ekman, 1992; Ortony, 2021), disgust's effects on memory and cognition are unique. Preliminary evidence suggests disgust is relevant to experiencing trauma and PTSD (Badour & Feldner, 2018; Chapman et al., 2013; Jones et al., 2020). Yet, research examining disgust's memorability has largely focused on *voluntary memory* and—to a lesser degree, *memory accuracy*—whereas less is known about disgust's memorability in contexts that are particularly relevant to PTSD and traumatic experiences more broadly (i.e,, intrusions and persistently remembering feelings of disgust). Thus, my thesis aims to bridge this gap. As an exploratory interest I also examine the relationship between memory for disgust and trait disgust, because people who easily and/or frequently experience disgust may, in turn, experience more frequent and vivid memories of disgust-eliciting situations (Bomyea & Amir, 2010). I also extend past research—which found a relationship between more intense *feelings* of disgust and more severe PTS symptoms (Badour et al., 2012; 2013a; 2013c; Bomyea & Allard, 2017)—by examining the relationship between disgust *memories* and PTS symptoms. Due to the important role memory plays in activating other PTSD symptoms, better understanding how we remember disgust may in part inform how to understand and treat trauma-related disgust responses in psychological therapies.

Chapter 2: Overview of Thesis Studies

The purpose of my thesis is to investigate disgust's memorability in the context of trauma. I compared memory for disgust *and fear* in all studies. Fear was a suitable comparison to understand the clinical significance of disgust's memorability, because fear is both recognised as a trauma-relevant emotion in PTSD diagnostic criteria and robustly associated with intrusive memories (and broader PTS symptoms; APA, 2022; Desmedt et al., 2015; Levin-Aspenson et al., 2021; Perry, 1999). The literature that currently exists on disgust's memorability (relative to fear) primarily focuses on *voluntary* memory frequency and memory recognition in a laboratory setting (e.g., Chapman et al., 2013; Chapman, 2018; Ferré et al., 2018; Moeck et al., 2021; Schienle et al., 2021). Therefore, my thesis aimed to bridge the gaps from this existing literature by investigating disgust's memorability (relative to fear) in relation to *involuntary memory* (frequency, characteristics, and intrusion symptom severity; Studies 1 and 2), *memory accuracy* (whilst addressing limitations from the pre-existing memory recognition literature; Study 3) and *memory for emotion* (Study 4). I examined disgust's memorability across both personal traumatic events and experimentally controlled settings. Further, because disgust and fear are both negative and arousing emotions, I experimentally controlled my disgust and fear stimuli on arousal and valence (Studies 2a, 2b and 3). As an exploratory interest, I also investigated the relationship between disgust memories, trait disgust (i.e., disgust propensity and sensitivity) and/or PTSD symptoms across all studies.

Chapter 3: Study 1

The existing literature on the relationship between trauma-related disgust reactions and intrusions is scarce and does not examine intrusion characteristics (Arnaudova & Hagenaars; Bomyea & Amir 2010). Given persistent intrusions that contain 'problematic' characteristics (e.g., distress and unwantedness) play an important role in activating and maintaining other PTSD symptoms (like avoidance; Bryant et al., 2017; Marks et al., 2018), my first thesis study (Chapter 3) aimed to establish whether trauma-related disgust reactions correlated with intrusion symptoms (i.e., severity and problematic characteristics). Furthermore, because disgust and fear reactions may co-occur during and/or after a traumatic event, I wanted to establish whether a relationship between disgust reactions and intrusion symptoms existed over and above fear reactions.

In an online survey, participants rated their disgust (and fear) reactions and completed a posttraumatic stress symptom measure in relation to a recent traumatic event. Participants also reported up to three intrusions for their traumatic event and rated these intrusions on several characteristics (e.g., distress). I found that disgust reactions uniquely predicted intrusion symptom severity, problematic intrusion characteristics and PTS symptoms, even after controlling for the effects of fear reactions. My findings suggest that trauma-related disgust reactions are related to intrusion symptoms implicated in PTSD (as well as PTS symptoms more broadly) to a comparable extent as trauma-related fear reactions. These results have important clinical implications, suggesting that trauma-related disgust reactions should not be overlooked in PTSD treatments.

Chapter 4: Studies 2a and 2b

In Study 1, I measured personal traumatic events using a correlational design. Whilst ecologically valid, I could not make robust conclusions regarding whether disgust memory enhancement (relative to fear) extends to intrusions. The limited existing research that measured disgust intrusions in a laboratory setting (using the trauma film paradigm) had not compared intrusions for the disgust stimuli with intrusions for other emotion-eliciting (e.g., fear) stimuli (Arnaudova & Hagenaars, 2017; Bomyea & Amir, 2010). Therefore, in Studies 2a and 2b, I experimentally compared involuntary memory (i.e., intrusion) frequency for disgust and fear (and neutral) stimuli. Specifically, I wondered whether enhanced voluntary memory for disgust relative to fear images (e.g., Chapman et al., 2013) extended to *involuntary* memory frequency. I had two additional aims. First, I examined whether involuntary memories of disgust images were more emotionally intense than involuntary memories of fear images. Second, given there was mixed evidence on the role of attention in disgust memory enhancement (Chapman, 2018; Chapman et al., 2013; Moeck et al., 2021), I aimed to clarify whether attention accounted for disgust involuntary memories.

To ensure a high degree of experimental control, I matched a set of disgust and fear images as closely as possible on well-known memory-enhancing variables (i.e., arousal, valence, distinctiveness, and organisation; e.g., Chapman, 2018; Chapman et al., 2013), and ensured the disgust images elicited high levels of disgust and low levels of fear (and vice versa for the fear images). In two experiments, participants viewed disgust, fear and neutral images during an attention-monitoring (encoding) task. Then participants recorded involuntary memories (and rated their emotional intensity) during a concurrent vigilance task and—in Study 2b only—over a 24-hour delay (via a paper diary). I found participants experienced more disgust than fear involuntary memories in Study 2a, but a similar number of disgust and fear involuntary memories in Study 2b. Whilst participants' disgust and fear involuntary memories were similarly emotionally intense post-encoding, disgust memories became more emotionally intense over the delay. My findings clarified that whilst participants paid more attention towards the disgust images, this enhanced attention did not account for disgust's involuntary memory frequency. Thus, disgust memory enhancement did not extend from voluntary to involuntary memory *frequency*. However, people experienced more emotionally intense disgust than fear memories over time, which has important clinical implications for PTSD, because emotionally intense intrusions activate and/or maintain persistent future intrusions (and other PTS symptoms; Bryant et al., 2017).

Chapter 5: Study 3

I had focused on *involuntary* memories for disgust thus far. In Study 3 I investigated *memory accuracy* (with a particular focus on false memories) for disgust (relative to fear). Existing research comparing memory recognition for disgust and fear found consistently low false memory rates and had methodological limitations (e.g., image lures matched the emotion category but not the emotional content of previously seen images; Chapman et al., 2013; Marchewka et al., 2016). Therefore, in Study 3 I compared false memories for disgust and fear image lures that depicted *related* content to previously seen images (e.g., participants viewed an image of rotten teeth at encoding, but a different rotten teeth image at test). Furthermore, to compare to past research and examine whether related image lures increase false memory rates, I also compared false memories for disgust and fear image lures that depicted *unrelated* content to previously seen images (e.g., participants viewed an image of a dirty toilet at test, though they had not viewed any dirty toilet images at encoding).

Like Studies 2a and 2b, I matched a set of disgust and fear images as closely as possible on well-known memory-enhancing variables (i.e., arousal, valence and distinctiveness), and participants viewed disgust and fear images during an attention-monitoring (encoding) task. Following a 24–48-hour delay, participants completed a recognition test where they viewed previously encoded (‘old’) and never seen (‘new’; related and unrelated) disgust and fear images. I found that participants experienced a similar number of disgust and fear false memories for related image lures, but more fear than disgust false memories for unrelated image lures. Participants had higher correct recognition rates, better memory sensitivity and a more liberal response bias for disgust relative to fear images. Thus, participants experienced more accurate memories, and fewer false memories, for disgust relative to fear images, which supported disgust memory enhancement. These findings emphasise disgust's strong memory trace, which informs why disgust reactions may be difficult to forget and/or manipulate, even in targeted intervention.

Chapter 6: Studies 4a and 4b

In Studies 1 – 3 I investigated memory for disgust (vs. fear) *content* (i.e., stimuli and personal experiences/intrusions) using various measurement types (i.e., intrusion symptoms, memory characteristics, memory frequency, memory accuracy). I had not yet investigated differences in memory for the disgust (and fear) *emotions* themselves, nor had any past research to my knowledge. This line of research is important because people are unable to retain the content of all past experiences in memory due to limited cognitive resources and therefore, it is efficient—and common—to remember the *emotions* associated with an event long after the details (i.e., content) of a past experience are forgotten (Levine et al., 2009). Furthermore, persistently experiencing negative emotions are a symptom of PTSD. Thus, in Studies 4a and 4b I wanted to know how trauma-related disgust persists in memory (relative to fear).

In two studies, participants rated their disgust (and fear) reactions to a recent traumatic event, both retrospectively (i.e., 'then') and at present (i.e., 'now'). In Study 4b, participants rated 'now' disgust (and fear) reactions again after a three-month delay. I found that whilst participants' disgust and fear reactions similarly persisted over time (i.e., Time 1 'now' compared to Time 2 'now' ratings), participants remembered more persistent feelings of disgust relative to fear (i.e., Time 1 'then' compared to Time 1 'now' ratings). Therefore, disgust's persistence in memory (relative to fear) reflected a memory bias (i.e., participants' memory of their past trauma-related disgust and fear reactions were likely influenced by their current disgust and fear reactions). My findings provide clinically useful insight into why intense disgust reactions may be harder to reduce (relative to intense fear reactions) in PTSD treatments—because feelings of disgust are more memorable than feelings of fear.

Chapter 3: Investigating the Relationship Between Disgust, and Intrusion Characteristics and Intrusion Symptom Severity

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Abstract

Disgust reactions commonly occur during/following trauma and predict posttraumatic stress (PTS) symptoms. Yet, disgust is not mentioned in DSM-5 PTSD criteria. To investigate disgust's clinical significance in PTSD, we measured the relationship between disgust (and fear) reactions to a personal trauma, and problematic intrusion characteristics (e.g., distress) and intrusion symptom severity. We focused on intrusions because they are a transdiagnostic PTSD symptom, though we also measured overall PTS symptoms to replicate prior work. Participants (N = 471) recalled their most traumatic/stressful event from the past six months. They then rated disgust and fear reactions to this event and completed the Posttraumatic Stress Disorder Checklist-5. Participants who had experienced intrusions about their event in the past month (n = 261) rated these intrusions on several characteristics (e.g., distress, vividness). We found stronger traumatic event-related disgust reactions were associated with more problematic intrusion characteristics, higher intrusion symptom severity, and higher overall PTS symptom severity. Notably, disgust reactions *uniquely* predicted these variables after statistically controlling for fear reactions. We conclude disgust

reactions to trauma may be similarly pathological to fear reactions for intrusion and broader PTS symptoms. Therefore, PTSD diagnostic manuals and treatments should recognise disgust as a trauma-relevant emotion.

Introduction

Consider someone who encounters a partially decomposed body while hiking. The person may experience several emotional reactions—perhaps horrified/frightened by their unexpected find, and/or disgusted by the decaying human remains. These reactions may lead the person to distance themselves from the body before contacting emergency services. The revulsion and avoidance response occurs because disgust is an adaptive, negative emotion that functions to protect against contamination (Badour et al., 2013a). Since disgust reactions occur for *physical* stimuli (e.g., bacteria, bodily fluids; Bomyea & Amir, 2010) and *moral* transgressions (e.g., exploitation, injustice; Curtis, 2011), various traumatic experiences elicit disgust reactions (Badour & Feldner, 2018). Such reactions are associated with posttraumatic stress (PTS) symptoms, with some researchers (Badour & Feldner, 2018; Coyle et al., 2014) suggesting this relationship's strength is comparable to *fear* reactions—an emotion robustly associated with PTSD (APA, 2022). However, scarce research has explored the association between disgust reactions to a traumatic event, and subsequent intrusions of that event, specifically. Disgust's manifestation in intrusion symptoms (i.e., intrusive thoughts and images) is an important research focus because intrusions are transdiagnostic in PTSD symptomatology and across other mental disorders (APA, 2022; Bryant et al., 2017; Cusack et al., 2016). Therefore, we explored disgust's significance in PTSD by comprehensively examining the relationship between traumatic event-related disgust (and fear, as a comparison) reactions and intrusions.

PTSD is typically associated with fear and anxiety, evidenced by a required "intense fear, helplessness, or horror" reaction to the traumatic event in historical diagnostic criteria

(Diagnostic and Statistical Manual of Mental Disorders 4th ed. [DSM-4]; APA, 1994). However, this emphasis on fear reactions is problematic. Many people with a trauma history—who would otherwise meet criteria for PTSD—present *without* fear, helplessness, or horror (Friedman et al., 2011). Indeed, negative emotional reactions—beyond fear—are uniquely associated with PTSD development and maintenance (Badour et al., 2013c; Hathaway et al., 2010; Power & Fyvie, 2013). Accordingly, in the DSM-5, PTSD has moved from an anxiety disorder to its own category 'Trauma-and Stressor-related Disorders', and diagnostic criteria broadened to include persistent negative reactions including anger, guilt, or shame (APA, 2022). Yet, *disgust* remains absent from PTSD criteria.

Disgust's absence from PTSD criteria is notable because various people exposed to trauma—including veterans (Bomyea & Allard, 2017) and victims of interpersonal violence (Coyle et al., 2014), natural disasters (Fredman et al., 2010), and industrial accidents (Grunert et al., 1992)—report disgust reactions during and following trauma. People with trait-like disgust vulnerabilities may be particularly susceptible to experiencing pathological disgust reactions following trauma (Badour & Feldner, 2018). These traits include disgust propensity (i.e., experiencing disgust easily and frequently), disgust sensitivity (i.e., perceiving disgust experiences as harmful), and trait moral disgust (i.e., tendency to avoid social norm violators). Indeed, disgust propensity predicts peritraumatic disgust reactions (Engelhard et al., 2011).

Disgust reactions are uniquely conditioned during trauma exposure. Whilst both disgust and fear form via classical conditioning (i.e., pairing a previously neutral stimulus with a disgust/fear reaction; Rozin & Fallon, 1987), disgust reactions can also form via evaluative conditioning (i.e., pairing a previously neutral stimulus with a hedonic value e.g., 'like/dislike'; Baeyens et al., 1992; Olatunji et al., 2007b). For example, consider a victim of sexual assault: the room where the assault occurred functions to *signal* the fear- and disgust-eliciting event may re-occur (i.e., classical conditioning), but the person may also evaluate *themselves* as dirty and disgusting after the incident (i.e., evaluative conditioning). Indeed, self-focused disgust (i.e., internalizing a disgust response associated with a traumatic experience, e.g., perceiving oneself as disgusting) is common following sexual trauma, formed via evaluative conditioning, and associated with higher PTS symptoms (Badour et al., 2014; Olatunji et al., 2008b). Thus, disgust's unique conditioning during/following trauma exposure likely has implications for PTS symptom development.

Indeed, disgust reactions are associated with *overall* PTS symptoms (Badour & Feldner, 2018; Hathaway et al., 2010), and uniquely predict PTS symptoms over and above fear reactions (Badour et al., 2013c). However, little is known about the association between disgust reactions during/following trauma and *intrusion* (or re-experiencing) symptoms. Intrusions are a hallmark PTSD symptom (APA, 2022). They are spontaneous/involuntary thoughts and images (e.g., memories, flashbacks, nightmares), and are common following traumatic events (but generally dissipate over time; Koren et al., 2001). Understanding disgust's manifestation in trauma-related intrusion symptoms is important because intrusions co-occur with—and are central to—other PTS symptoms. In one example, among people hospitalised following trauma exposure, intrusions strongly correlated with other PTS symptoms (e.g., avoiding trauma-related thoughts, increased arousal/physiological reactions and being upset by trauma-related reminders) during both the acute phase (i.e., within one week following trauma exposure) and at 12-month follow up (Bryant et al., 2017). These findings suggest intrusions are central to PTS symptom development and maintenance, and are thus an appropriate target for PTS research and intervention. Furthermore, intrusions are transdiagnostic across other mental disorders where disgust reactions occur (i.e., Obsessive Compulsive Disorder [OCD] and Specific Phobia; APA, 2022; Böhnlein et al., 2020; McKay, 2006).

A relationship between trauma-related disgust reactions and intrusion symptoms is plausible due to disgust's emotionally negative and arousing nature (Chapman et al., 2013). Dimensional emotion models (e.g., Russell, 1980) suggest valence (i.e., emotional positivity or negativity) and arousal (i.e., alertness) enhance memory (termed 'emotionally enhanced memory'; Cahill & McGaugh, 1995). Indeed, fear is robustly associated with intrusion symptoms (Levin-Aspenson et al., 2021). Because disgust experiences are similarly negative and arousing to fear experiences (Chapman et al., 2013), this theoretical basis also leads us to expect disgust reactions will be associated with intrusion symptoms.

Existing research regarding the link between disgust and intrusions is scarce and focused on intrusion frequency in the lab: in one study, participants experienced intrusions (4-5 on average) shortly after viewing a trauma film displaying severe burns (Bomyea & Amir, 2010). Despite demonstrating intrusions can occur for disgust-eliciting stimuli, this study has four key limitations. First, because data collection occurred within a single session—with intrusions monitored for 5-minutes—the findings only represent intrusion *onset*, not persistence (a common intrusion severity measure). Second, participants' emotional reactions to the film were not measured; disgust reactions were assumed, not confirmed. Third, the *analogue* approach has limited ecological validity; it is not as immersive and self-relevant as experienced trauma (James et al., 2016). Finally, participants did not rate their intrusions on characteristics (e.g., distress), or evaluate whether those intrusions elicited disgust. Exploring how disgust reactions—indexed both to the trauma and to subsequent intrusions—relate to intrusion-specific characteristics is important because these characteristics predict whether intrusions will become problematic and persist (Marks et al., 2018).

Marks et al.'s intrusive retrieval feedback loop (2018) models how problematic intrusion characteristics increase intrusion severity and other PTS symptom clusters.

According to this model, intrusion symptoms are maintained through a cyclical process in three ways. First, experiencing distress during an intrusion increases the memory trace-strength (i.e., retrieval ease), thus increasing the intrusion's persistence and future associated distress. Second, other 'problematic' intrusion retrieval characteristics associated with traumatic experiences (i.e., vividness, emotional intensity, nowness/re-living) exacerbate intrusion-related distress (Berntsen, 2001; Marks et al., 2018). Third, these problematic intrusion characteristics reinforce maladaptive processing (e.g., appraising the intrusion as negative, unwanted), further increasing the likelihood of future persistent and distressing intrusions. Thus, it is imperative we understand how disgust reactions predict intrusion characteristics and severity, because these factors are central to PTS symptom manifestation.

The current study

Our primary interest was to examine disgust reactions and intrusion symptoms (characteristics, severity) related to participants' most stressful or traumatic event from the past six months. We also measured overall PTS symptoms to replicate previous studies (Badour & Feldner, 2018; Badour et al., 2013c; Curtis, 2011). We hypothesised stronger traumatic event-related disgust reactions (termed 'event-related disgust') would be associated with: [1] problematic intrusion characteristics (i.e., negative valence and higher distress, vividness, unwantedness, nowness, emotional intensity ratings), [2] higher intrusion symptom severity scores (e.g., persistent memories over one-month), and [3] higher overall PTS symptom scores. To determine these disgust-related associations' clinical significance, we also measured fear reactions to the same traumatic event (termed 'event-related fear'). Fear reactions are recognised in PTSD diagnostic criteria and are robustly associated with intrusion and overall PTS symptoms, thus a suitable comparison (APA, 1994; 2022; Levin-Aspenson et al., 2021).

We had three subsidiary interests. First, we examined whether intrusion-related disgust reactions (termed 'intrusion-related disgust') moderated the intensity between event-related disgust and intrusion symptoms' relationship. Second, we examined whether event-related disgust predicted intrusion symptoms (and PTS symptoms, to replicate Badour et al., 2013c) after statistically controlling for event-related fear. Third, we examined whether trait disgust predicted event- and intrusion-related disgust. We aimed to replicate Engelhard et al.'s (2011) finding that disgust propensity predicts event-related disgust reactions, and extend these findings by also evaluating disgust sensitivity—also shown to predict PTS symptoms (Badour et al., 2012)—trait moral disgust, and intrusion-related emotional reactions. Therefore, we hypothesised trait disgust would predict event- and intrusion-related disgust.

We pre-registered this study on the Open Science Framework (https://osf.io/b249a/) where the data (https://osf.io/3t57m/), study materials (https://osf.io/bfc4p) and supplementary material (https://osf.io/r5fgy) are publicly available.

Study 1

Method

We report how we determined sample size and all data exclusions, manipulations, and measures in the study (Simmons et al., 2012). The Flinders University Social and Behavioural Research Ethics Committee approved this research.

Participants

Correlations stabilize when sample size approaches 260 (Schönbrodt & Perugini, 2013; 2018). Therefore, we collected data until we had 260 participants with at least one intrusion. We recruited 474 participants from Amazon Mechanical Turk (MTurk). We took the following pre-registered steps to ensure quality data. To prevent bots/server farmers from completing the survey, participants had to pass pre-screening questions: a captcha, an arithmetic question (i.e., 3+4=) presented as an image, and score at least 8/10 on an English

Proficiency Test (Moeck et al., 2022) to start the survey. We embedded three attention checks (e.g., "If you are reading this, please select option 5") and one open-ended question about the study's purpose within the survey. We excluded three participants: two provided answers consistent with bots/farmers to the open-ended question (e.g., "nice") and one failed all three attention checks (Agley et al., 2021).

Our final sample comprised 471 participants ranging from 19–88 years (M = 42.7, SD = 13.1); roughly half were women (52.7%, men = 45.9%, non-binary = 0.6%, prefer not to say = 0.9%). Most participants were American (including "African American", "Native American", "Chinese American" and "European American", 94.5%). Others were Chinese (0.4%); Korean (0.4%); Bahamian (0.2%); Malaysian (0.2%); Indian (0.2%); Vietnamese (0.2%); Puerto Rican (0.2%); Russian (0.2%); German (0.2%). Some provided their ethnicity instead of nationality (e.g., "White" and/or "Caucasian", 2.8%; "Asian", 0.4%).

Materials

Trauma History Screen (THS; Carlson et al., 2011). The THS measures exposure to high magnitude stressor (HMS) events (i.e., sudden events that cause extreme distress in most people; e.g., *seeing someone die suddenly or get badly hurt or killed*), satisfying DSM-4 PTSD Criterion A1 (APA, 1994). We adapted the THS to measure exposure in the last six months to control for time since the event, and because memories are retrieved easier for recent events (Rubin & Berntsen, 2009). Therefore, we removed items referring to childhood events. Participants indicated whether they experienced any of the remaining 12-HMS events within the last six months. Participants then indicated whether the event/s "*really bothered [them] emotionally*" (*yes/no/I did not experience any of the events*). If *Yes,* participants briefly described the event that bothered them the most, classified as their most traumatic event from the last six months. If *No* or *I did not experience any of the events*, participants briefly described their most stressful event from the last six months. Then, all participants indicated how long ago (*months/days*) their most traumatic/stressful event occurred, how much they were bothered by the event (*1 = not at all, 5 = very much*), and for how long (*1 = not at all, 4 = a month or more*). The THS has excellent 1-week test-retest reliability (.93) and good convergent validity (r = .32, p < .001, correlated with the Screen for Posttraumatic Symptoms; Carlson et al., 2011). All participants reported either a traumatic (i.e., HMS; n = 218) or stressful (i.e., non-HMS; n = 253) event (see Supplementary Table S3.2 for specific event category descriptions). We include responses to both 'traumatic' and 'stressful' events in analyses because people can otherwise meet PTSD criteria for traumatic/stressful events incongruent with Criterion A1 (e.g., Bridgland et al., 2021; Gold et al., 2005). Following the THS, participants answered all measures in relation to their most traumatic/stressful event from the last six months.

Emotional reactions. Participants rated how intensely they felt/feel four specific emotions (fear, disgust, anger, compassion; *1 = not at all, 7 = extremely*) both at the time their most traumatic/stressful event occurred (i.e., then), and when they presently think about the event (i.e., now). We measured these emotional reactions using single-items, previously extensively used to investigate peri- and post-traumatic emotional intensity (e.g., Badour et al., 2013c; Engelhard et al., 2011; Hathaway et al., 2010). We included *compassion*—a posttraumatic growth-related emotion (Tedeschi & Calhoun, 2004)—and *anger*—a PTSD-relevant emotion (APA, 2022)—to deter participants from guessing the study's hypotheses.

In addition to measuring disgust generally, we explored differences in disgust *type* in a separate question set: participants rated the extent they felt/feel physically disgusted (i.e., *dirty, contaminated, revolted, deformed, diseased*) and morally disgusted (i.e., *your/others' rights were violated, you were exposed to behaviour that you consider socially/morally unacceptable/revolting*) both when the event occurred, and when presently thinking about the event. This distinction between physical and moral disgust extends existing research that measured disgust as one emotion-type (e.g., Badour et al., 2013c). Because we measured various disgust types (i.e., disgust, physical disgust, moral disgust), we interchangeably refer to the overall disgust rating as "disgust" or "general disgust" when also discussing the other disgust types. We randomised the order of all emotional reaction items and counterbalanced the order of the then/now questions between-subjects.

Posttraumatic Stress Disorder Checklist (PCL-5; Weathers et al., 2013). The PCL-5 comprises 20 items assessing PTSD symptoms in the past month, or since participants' nominated event occurred if less than a month ago (i.e., *'Repeated, disturbing, and unwanted memories of the stressful experience'*; 1 = *not at all*, 5 = *extremely*). The PCL-5 comprises four subscales: re-experiencing, avoidance, negative alterations in cognition and mood, and alterations in arousal and reactivity. Re-experiencing subscale scores represented our *intrusion symptom severity* measure. The PCL-5 had high internal consistency in the current study (re-experiencing subscale: α = .90; overall: α = .95) and strong convergent validity (r = .84, p < .001, correlated with the Detailed Assessment of Posttraumatic Symptoms–Posttraumatic Stress Scale; Blevins et al., 2015).

Involuntary Cognitions Questionnaire (ICQ; e.g., Oulton et al., 2018). We measured the content and characteristics of intrusions related to participants' most traumatic/stressful event. Participants indicated '*yes*'/'*no*' as to whether they experienced any intrusions about the event within the past month, reducing pressure to report *voluntary* memories. If '*yes'*, participants described their most recent intrusion's content and rated how intensely (*1 = not at all, 7 = extremely*) they felt/feel emotions associated with the intrusion. We used the same specific emotions as for the event itself (fear, disgust, anger, compassion), randomised. To check the intrusion was involuntarily (i.e., unintentionally and easily) retrieved, participants rated their intrusion on two retrieval intent items (e.g., *The memory came to mind spontaneously at the time it occurred)* and two retrieval ease items (e.g., *The* *memory came to mind effortlessly*). Participants then rated their intrusion on six characteristics: distress, vividness (i.e., detailed/clear imagery), unwantedness (i.e., efforts made to avoid the memory), nowness (i.e., felt the event was happening 'right now'), emotional intensity (i.e., impactful emotional reactions paired with the memory; *1 = not at all, 7 = extremely/completely*), and valence (*1 = extremely negative, 7 = extremely positive*). After completing this process for their most recent intrusion, we asked participants whether they had experienced any *other* intrusions about the event within the past month (*yes*/*no).* If *yes*, they answered the same questions in the same order until they said they had experienced no other intrusions or had described three intrusions.

Trait Disgust. We used two scales to assess whether individual differences in trait disgust predicted disgust-related intrusions and PTSD symptoms. We focused on disgust propensity, disgust sensitivity, and trait moral disgust (i.e., perceiving everyday moral transgressions as disgusting).

The modified Disgust Propensity and Sensitivity Scale – Revised (DPSS-R; Goetz et al., 2013, adapted from van Overveld et al., 2010) comprises disgust propensity and disgust sensitivity subscales. Two items were removed from the disgust sensitivity subscale in the modified DPSS-R (e.g., "It embarrasses me when I feel disgusted", because exploratory factor analyses revealed they instead measure self-focused/ruminative disgust; Goetz et al., 2013). Thus, six items measure disgust propensity (e.g., "I avoid disgusting things") and four measure disgust sensitivity (e.g., "When I feel disgusted, I worry that I might pass out"; *1= never, 5 = always*). The modified DPSS-R has good internal consistency (current study: α = .78 for Propensity, α = .79 for Sensitivity). The modified DPSS-R has strong convergent validity with the Core Disgust subscale of the Disgust Scale – Revised ($r = .61$, $p < .001$ for Propensity; $r = .46$, $p < .001$ for Sensitivity; Goetz et al., 2013).

The Moral Disgust subscale of the Three Domains of Disgust Scale (TDDS; Tybur et al., 2009) measures disgust sensitivity to non-violent moral violations. The scale has seven items (e.g., "Forging someone's signature on a legal document"; *0 = not at all disgusting, 6 = extremely disgusting*). The TDDS Moral Disgust subscale has high internal consistency (current study: $\alpha = .93$) and good discriminant validity from the Primary Psychopathy Scale, measuring antisocial attitudes ($r = -.38$, $p < .05$; Tybur et al., 2009).

Procedure

After passing pre-screening (reCAPTCHA, English Proficiency Test etc.), participants provided demographic information (i.e., sex, gender, age, nationality). They then indicated their most traumatic event in the last six months (using the THS), followed by several questionnaires in relation to that event: emotional reactions to the event (then/now), then PTS symptom (PCL-5) and intrusion (ICQ) measures. Finally, they completed the two trait disgust scales in counterbalanced order. We fully debriefed participants and provided them with support and services for any emotional discomfort experienced. Participants received $1.20USD; the survey took approximately 14-min to complete.

Results

Analyses involving intrusion characteristic variables (i.e., ICQ ratings) use the sub-sample of 261 participants[3] who reported at least one intrusion (194 reported one intrusion, 60 reported two intrusions, and seven reported three intrusions). For the remaining analyses, we focus on the full sample ($N = 471$) to maximise statistical power. Notably, the pattern of results was similar whether we used the full ($N = 471$) or sub-sample ($n = 261$). Demographics for the sub-sample used in the intrusion characteristic analyses appear in Supplementary Table S3.1.

Preliminary Analyses

[3] Except $n = 260$ for the ICQ 'nowness' measure due to missing data

First, we examined whether participants responded similarly for general disgust, physical disgust, and moral disgust reactions. They generally did; therefore, we only report general disgust reaction analyses. We explicitly state any inconsistencies depending on disgust type (general, physical, moral). Analyses separating physical and moral disgust reactions are reported in supplementary material.

Next, we considered whether disgust and fear ratings when the event occurred (i.e., then) and when presently thinking about the event (i.e., now) could be combined into an average score for easier interpretation. Participants' 'then' and 'now' disgust reactions strongly positively correlated, $r = .83$, $p < .001$. Therefore, as pre-registered, we combined 'then' and 'now' event-related disgust for all analyses.[4] For easier comparison, we did the same for fear reactions despite the correlation between then/now ratings ($r = .64$, $p < .001$) falling slightly below our pre-registered cut-off ($r > .70$). Notably, results were similar whether we used 'then', 'now' or combined (then and now) event-related disgust and fear ratings[5]. There were small-to-moderate correlations between event-related disgust and fear ($r = .28$, $p < .001$ for 'then'; $r = .38$, p < .001 for 'now'), suggesting the ratings were distinct rather than capturing negative affect in general. Because participants could report up to three intrusions, we used average ratings for each intrusion characteristic (e.g., distress; as in Oulton et al., 2018).

Table 3.1 displays descriptive statistics for variables used in the main analyses. Most participants (68.4%) experienced a HMS event within the past 6 months (see Supplementary Table S3.2 for percentages of specific THS event types). Participants' disgust and fear reactions for their nominated event were moderate, relative to the rating scale. On average,

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[4] Analyses comparing 'then' and 'now' data (using an independent t-test) are reported in a separate manuscript.
[5] ICQ valence ratings were an exception, where intrusion negativity had a smaller association with fear reactions after a period of time. Specifically, the correlation with ICQ valence was stronger for 'then' ($r = -.34$) compared to 'now' ($r = -.19$) fear reactions, whereas the correlation for ICQ valence remained stable for 'then' ($r = -.34$) and 'now' ($r = -.35$) disgust reactions.

participants reported subthreshold PTSD symptom levels, based on the PCL-5 cut-off (31; Ashbaugh et al., 2016). According to this cut-off, approximately one third of the sample (28.9%, *n* = 136) were PTSD-probable.

Table 3.1

Descriptive Statistics for Main Variables

Measures	Scale	Range	Mean (SD)
Event-related disgust	1–7	1–7	2.7 (2.0)
Event-related fear	1–7	1–7	3.8 (1.9)
PCL total	0–80	0–80	23.0 (17.4)
PCL re-experiencing	0–20	0–20	6.6 (5.2)
PCL avoidance	0–8	0–8	2.8 (2.4)
PCL negative alterations in cognition and mood	0–28	0–28	7.8 (6.7)
PCL alterations in arousal and reactivity	0–24	0–24	5.9 (5.2)
ICQ disgust	1–7	1–7	3.0 (2.3)
ICQ fear	1–7	1–7	3.9 (2.4)
ICQ retrieval intent	1–7	3–7	6.3 (1.0)
ICQ retrieval ease	1–7	2–7	5.3 (1.2)
ICQ distress	1–7	1–7	5.3 (1.6)
ICQ vividness	1–7	3–7	6.0 (1.1)
ICQ unwantedness	1–7	1–7	5.2 (2.0)
ICQ nowness	1–7	1–7	4.7 (1.7)
ICQ emotional intensity	1–7	2–7	5.5 (1.3)
ICQ valence	1–7	1–7	2.5 (1.7)
DPSS-R disgust propensity	6–30	6–30	17.2 (4.1)
DPSS-R disgust sensitivity	4–20	4–20	9.6 (3.7)
TDDS moral disgust	0–42	0–42	26.0 (10.6)

Note. N = 471 for event-related disgust, event-related fear, PCL, DPSS-R and TDDS measures; n = 261 for ICQ measures (except n = 260 for 'ICQ nowness'). PCL = Posttraumatic Stress Disorder Checklist; ICQ = Involuntary Cognitions Questionnaire; DPSS-R = Disgust Propensity and Sensitivity Scale – Revised; TDDS = Three Domains of Disgust Scale. ICQ retrieval intent: higher scores indicate unintentional retrieval. ICQ retrieval ease: higher scores indicate retrieval ease.

We next examined whether participants' reported intrusions were involuntary (rather than voluntary), indexed by high retrieval ease and non-intentional retrieval (Berntsen, 2010). Participants' intrusion intent ratings (M = 6.3, SD = 1.0) were significantly higher than the scale anchor ('1') for intentional retrieval, $t(260) = 90.07$, $p < .001$, $d = 0.95$, 95% CI [6.22, 6.34]. Participants' intrusion retrieval ease ratings (M = 5.3, SD = 1.2) were significantly higher than the scale anchor ('1') for low retrieval ease, $t(261) = 58.40$, $p < .001$, $d = 1.19$, 95% CI [5.22, 5.36]. The two ratings were moderately positively correlated ($r = .29$, $p < .001$, 95% CI [.17, .40]). These findings suggest, on average, reported intrusions were involuntary. We thus report analyses for *all* intrusions, however, note when we excluded 24 participants who scored <4 (the scale midpoint) on intent and/or retrieval ease, and removed 30 individual intrusions scored <4 on intent and retrieval ease from our main analysis, the findings did not change.

Inferential Statistics

We turn to our main research question: are disgust reactions to a recent traumatic event associated with intrusion characteristics and intrusion symptom severity? We examined correlations between event-related disgust and intrusion characteristics, intrusion symptom severity (i.e., PCL-5 re-experiencing subscale) and overall PTS symptoms (Table 3.2). To demonstrate these disgust-related correlations' clinical significance, Table 3.2 includes correlations with event-related fear—an emotion central to PTSD symptoms (Levin-Aspenson et al., 2021). Furthermore, Table 3.2 displays Z-score comparisons between disgust- and fear-related correlations, where nonsignificant scores indicate similarity between the two correlations (Steiger, 1980)—which occurred for most correlations.

As hypothesised, event-related disgust positively correlated with intrusion distress, unwantedness, 'here-and-now' qualities, emotional intensity and negative valence, but—contrary to our hypothesis—did not correlate with intrusion vividness (Bonferroni-adjusted for six characteristics; $p < .008$). Correlations with intrusion distress, unwantedness, and negative valence were moderate in size, while correlations with intrusion nowness and emotional intensity were small. Notably, the correlation between event-related disgust and intrusion vividness *was* significant when we considered only participants who experienced a HMS event ($n = 218$, see Supplementary Table S3.14), suggesting intrusion vividness is associated with more severe disgust-related stressors.

Also consistent with our hypothesis, event-related disgust moderately positively correlated with intrusion *symptoms* (i.e., PCL-5 re-experiencing subscale). Event-related disgust also strongly positively correlated with overall PTS symptoms. Therefore, intense disgust reactions to a recent trauma experience are not only related to more severe intrusion symptoms, but also to more severe avoidance, negative alterations in cognition and mood, and alterations in arousal and reactivity (Bonferroni-adjusted for four PCL-5 subscales; $p < .013$). Overall, disgust reactions are associated with intrusion symptoms (characteristics and severity), *and* PTS symptoms more broadly, suggesting disgust's role in PTSD has been underestimated.

Table 3.2

Correlation Coefficients for Disgust and Fear Reactions to a Recent Traumatic Event and Correlation Comparisons (Z Test), and Intrusion Characteristics, Intrusion Symptom Severity and Overall PTS Symptoms With 95% Confidence Intervals

	Disgust Reaction to Event	Fear Reaction to Event	*Z* Test
ICQ distress	.38** [.27, .48]	.43** [.33, .53]	-0.85
ICQ vividness	.14 [.02, .26]	.17* [.05, .26]	-0.33
ICQ unwantedness	.33** [.22, .44]	.37** [.27, .47]	-0.62
ICQ nowness	.23** [.11, .34]	.37** [.27, .47]	-2.16*
ICQ emotional intensity	.22** [.11, .34]	.28** [.16, .38]	-0.75
ICQ valence	-.36** [-.46, -.25]	-.30** [-.40, -.18]	-0.96
Intrusion severity (PCL-5 re-experiencing)	.47** [.39, .53]	.48** [.41, .55]	-0.24
PCL-5 total	.53** [.46, .59]	.53** [.46, .59]	0.07
PCL-5 avoidance	.36** [.28, .44]	.35** [.26, .42]	0.22
PCL-5 negative alterations in cognition and mood	.52** [.45, .59]	.48** [.41, .55]	0.66
PCL-5 alterations in arousal and reactivity	.47** [.40, .54]	.50** [.43, .56]	-0.48

Note. N = 471 for PCL measures; n = 261 for ICQ measures (except n = 260 for 'ICQ nowness'); * $p < .05$, ** $p < .001$; significant p value on the Z Test indicates a significant difference between the disgust- and fear- reaction correlation.

The correlation results revealed stronger event-related disgust was associated with greater intrusion characteristic and intrusion symptom severity scores. To extend these findings, we turn to our first subsidiary interest: whether intensity of *intrusion*-related disgust moderated the relationships between *event*-related disgust, and intrusion characteristics and intrusion symptom severity. We expected intrusions that elicited greater disgust would strengthen these relationships. Because the intrusion characteristic scores had good internal consistency (distress, vividness, unwantedness, nowness, emotional intensity, negative valence[6]; $\alpha = .79$), we calculated an average "problematic intrusion characteristics" score for each participant, as pre-registered.

We ran multiple linear regression analyses, testing for a significant interaction between intrusion- and event-related disgust (see Table 3.3). Together in Step 1, event- and intrusion-related disgust explained 20.8% of the variance in problematic intrusion characteristics and 20.3% of the variance in intrusion symptom severity. However, when accounting for the interaction between event- and intrusion-related disgust in Step 2, the models were no longer significant. Therefore, stronger intrusion-related disgust *did not* moderate the strength of the relationship between event-related disgust and problematic intrusion characteristics. Additionally, stronger intrusion-related disgust *did not* moderate the strength of the relationship between event-related disgust and higher intrusion symptom severity scores. These findings suggest event- and intrusion-related disgust are not dependent on one another—but rather are independently related to problematic intrusion characteristics and intrusion symptom severity. Alternatively, the lack of moderation may be due to only one of the two predictors—intrusion- and event-related disgust—significantly predicting each outcome variable: intrusion-, but not event-related, disgust significantly predicted problematic intrusion characteristics, while event-, but not intrusion-related, disgust significantly predicted intrusion symptom severity. These contrasting effects may be due to mismatches in questionnaire wording between the predictor and outcome variables. Specifically, language in the ICQ (measuring intrusion-related disgust and intrusion

[6] See Supplementary Table 19 for correlations between each memory characteristic variable.

characteristics) was directed towards participants' *intrusions* whereas language in the PCL-5 (measuring intrusion symptom severity) was directed towards participants' *traumatic/stressful event* (as for the event-related emotional reactions questions). In other words, pairs of variables with similar questionnaire wording yielded significant relationships.

Table 3.3

Inferential Statistics From Regression Analyses on Intrusion-Related Disgust as a Moderator Between Event-Related Disgust, and Problematic Intrusion Characteristics and Intrusion Symptom Severity

	Beta	Variance explained (%)	R^2	R^2_{change}	F	F_{change}	df	p
Problematic Intrusion Characteristics								
1. Event-related disgust	.03	19.5	.20		31.33		2, 258	< .001
Intrusion-related disgust	.42**							
2. Event-related disgust	.04	19.6		.0004		0.14	1, 257	.71
Intrusion-related disgust	.43**							
Event-related * Intrusion-related disgust (interaction)	-.03							
Intrusion Symptom Severity (PCL-5 re-experiencing subscale)								
1. Event-related disgust	.35*	20.3	.20		32.83		2, 258	< .001
Intrusion-related disgust	.11							
2. Event-related disgust	.37*	20.5		.002		0.70	1, 257	.40
Intrusion-related disgust	.13							
Event-related * Intrusion-related disgust (interaction)	-.06							

Note. n = 261; * = p < .03; ** p < .001; n = 218

Next we turn to our second subsidiary interest: whether event-related disgust predicts intrusion characteristics and intrusion symptom severity after statistically controlling for event-related fear. We ran three hierarchical multiple regression models to determine if event-related disgust predicted average problematic intrusion characteristic scores, intrusion symptom severity scores and overall PTS symptom scores, *after* statistically controlling for event-related fear (see Table 3.4)[7]. Together, event-related disgust and fear significantly predicted problematic intrusion characteristic scores, intrusion symptom severity scores, and overall PTS symptom scores. Event-related disgust explained an additional 6.7% of the variance in intrusion characteristic scores, 10.1% of the variance in intrusion symptom severity scores, and 13.5% of the variance in overall PTS symptom scores. Put another way, disgust reactions to the traumatic event significantly predicted intrusion characteristics, intrusion symptom severity, and overall PTS symptom scores, *over and above* fear reactions. Therefore, disgust has a unique role in intrusion and overall PTS symptomatology following recent traumatic events.

[7] Analyses with gender as a covariate appear in Supplementary Table 18.

Table 3.4

Inferential Statistics From Regression Analyses on Event-Related Disgust as a Predictor of Problematic Intrusion Characteristics, Intrusion Symptom Severity and PTS Symptoms, After Controlling for Event-Related Fear

	Beta	Variance explained (%)	R^2	R^2_{change}	F	F_{change}	df	p
Problematic Intrusion Characteristics								
1. Fear reactions	.44	19.0	.19		60.61		1, 259	< .001
2. Fear reactions, Disgust reactions	.34 .28	25.7		.07		23.32	2, 258	< .001
Intrusion Symptom Severity (PCL-5 re-experiencing subscale)								
1. Fear reactions	.48	23.1	.23		140.53		1, 469	< .001
2. Fear reactions, Disgust reactions	.36 .34	33.1		.10		70.41	2, 468	< .001
PTS Symptoms (PCL-5 total score)								
1. Fear reactions	.53	27.5	.28		178.26		1, 469	< .001
2. Fear reactions, Disgust reactions	.39 .39	41.0		.14		107.19	2, 468	< .001

Note. $N = 471$ for Intrusion Symptom Severity and PTS Symptoms; $n = 261$ for Problematic Intrusion Characteristics; $p < .001$ for all Beta coefficients

Recall our final subsidiary interest in whether trait disgust (disgust propensity, disgust sensitivity and trait moral disgust) is associated with disgust reactions (event- and intrusion-related) following a traumatic event. A linear regression analysis revealed trait disgust explained 12.2% of the variance in event-related disgust ($F(3, 467) = 21.71$, $p < .001$) and 20.7% of the variance in intrusion-related disgust ($F(3, 257) = 22.39$, $p < .001$). Disgust propensity scores significantly added to the prediction (event-related general disgust: $b = .165$, $p < .001$; intrusion-related general disgust: $b = .23$, $p < .001$), whereas disgust sensitivity scores (event-related: $b = .02$, $p = .60$; intrusion-related: $b = .07$, $p = .15$) did not. Interestingly, disgust sensitivity scores only significantly predicted event- and intrusion-related *physical disgust* (see Supplementary Table S3.17). Trait moral disgust scores did not predict event- ($b = .001$, $p = .93$) or intrusion-related ($b = .07$, $p = .15$) disgust. Overall, these regression findings suggest people with higher *disgust propensity* (i.e., those who experience disgust easily and frequently) may experience stronger disgust during and following traumatic events, and during trauma-related intrusions. However, *disgust sensitivity* (i.e., perceiving disgust experiences as negative and harmful) only predicts stronger event- and intrusion-related *physical disgust*.

Discussion

The current study measured the relationship between traumatic event-related disgust reactions, intrusion symptoms (i.e., problematic characteristics and severity) and overall PTS symptom severity. There were three key findings. First, as hypothesised, stronger disgust reactions to a recent traumatic/stressful event were associated with more problematic intrusion characteristics like distress, higher intrusion symptom severity, and higher overall PTS symptom severity related to that event. *Intrusion*-related disgust did not affect the strength of these associations. Second, these findings replicated after statistically controlling for event-related fear. Finally, trait disgust—particularly disgust propensity (i.e., ease/frequency in experiencing disgust)—predicted stronger event- and intrusion-related disgust. Our findings are consistent with previous research demonstrating disgust's unique association with PTS symptomatology, over and above fear (Badour et al., 2013c). We extend prior findings by revealing disgust is uniquely associated with intrusion characteristics and severity—transdiagnostic in PTSD symptomatology—over and above fear.

Our findings provide novel insight into disgust's relevance to problematic intrusion characteristics, central to PTS symptom manifestation (Marks et al., 2018). We found an association between stronger event-related disgust, and intrusions characterised as more distressing, unwanted, occurring in the here-and-now, emotionally intense, and negative. Although these data are correlational, they suggest one way disgust may increase intrusion frequency—as Bomyea and Amir (2010) observed—is by promoting problematic intrusion characteristics. According to autobiographical memory literature (e.g., Berntsen, 2001) and the intrusive feedback loop model (i.e., Marks et al., 2018), experiencing an intrusion accompanied by these problematic characteristics increases a person's arousal and stress during retrieval. Increased arousal and stress then increases the intrusion's memory trace strength and accessibility, increasing intrusion persistence (Rubin & Berntsen, 2009; Marks et al., 2018; McGaugh, 2004). Of course, these intrusion characteristics are not exclusive to disgust reactions, and such characteristics would also exacerbate intrusion accessibility and persistence for intrusions related to other negative emotions, like *fear*.

Our findings suggest disgust reactions following trauma exposure may be similarly pathological—regarding PTSD—to fear reactions. Like fear, disgust reactions were associated with certain intrusion characteristics explicitly mentioned in PTSD diagnostic manuals (i.e., distress, nowness, unwantedness), and with intrusion symptom severity on the PCL-5. We acknowledge our findings are limited to retrospective reports of intrusion symptoms over a relatively short duration (i.e., 1-month). Thus, future research should longitudinally investigate the influence of traumatic event-related disgust on intrusion persistence, ideally using experience-sampling methods to reduce retrospective reporting biases. Nevertheless, our findings—paired with previous research demonstrating disgust's enhancement (relative to fear) in autobiographical memory (e.g., Moeck et al., 2021)—suggest intrusions for traumatic events that elicit disgust reactions may be similarly pathological to intrusions for traumatic events that elicit fear.

Crucially, event-related disgust predicted intrusion symptoms (i.e., characteristics and severity) and overall PTS symptoms, over and above event-related fear. These results replicate and extend existing findings (i.e., Badour et al., 2013c) and validate conditioning processes (i.e., classical and evaluative; Badour & Feldner, 2018), suggesting disgust has a *unique* role in PTSD development and maintenance. Consequently, disgust reactions should be explicitly targeted in PTSD. Yet, disgust reactions may be relatively treatment resistant to exposure therapy (Badour & Feldner, 2018; Mitchell et al., 2024)—a strongly endorsed PTSD treatment (Institute of Medicine et al., 2008)—and therefore *maintained* in PTSD symptom trajectories. Indeed, a slower habituation trajectory (i.e., reduction in a learned emotional response's intensity and frequency) for disgust compared to fear reactions during exposure therapy has been observed among people with PTSD and OCD (Harned et al., 2015; Mason & Richardson, 2012; McKay, 2006; Olatunji et al., 2009). Perhaps disgust is not meaningfully habituated in these studies because habituating *fear* is generally the objective of exposure therapy. In other words, therapists may overlook disgust as a target for exposure therapy. Indeed, specifically targeting disgust during exposure therapy (i.e., by evoking the emotion during behavioural experiments) has proven successful in reducing symptoms among people with a Specific Phobia (Böhnlein et al., 2020). Another potential solution to appropriately addressing disgust in PTSD treatment is supplementing exposure therapy with cognitive and behavioural therapies that change disgust's evaluative meaning (e.g., imagery rescripting, increasing disgust tolerance by challenging beliefs about disgust intolerance). Such approaches have proven successful in treating OCD (Fink-Lamotte et al., 2018), Specific Phobias (Böhnlein et al., 2020) and eating disorders (Plasencia et al., 2019).

Our results also suggest people may be more vulnerable to experiencing disgust reactions in response to traumatic events if they possess high trait disgust. Consistent with existing research (e.g., Bomyea & Amir, 2010), we found disgust *propensity* was associated with stronger event- and intrusion-related disgust. By contrast, higher disgust *sensitivity* was only associated with stronger event- and intrusion-related *physical* disgust (i.e., feeling dirty, diseased)—likely because these explicit disgust examples refer to contaminants, which may be more objectively harmful than moral disgust. We did not find a significant relationship between trait moral disgust, and event- or intrusion-related disgust, perhaps because the items on the TDDS moral disgust scale were consistent with moral transgressions not typically deemed traumatic (e.g., "shoplifting a candy bar from a convenience store"). Alternatively, this scale's items may elicit anger, rather than disgust reactions, raising doubt about its construct validity (Olatunji et al., 2012). Nevertheless, people with high disgust propensity may have increased event-related disgust, which may ultimately increase risk of *developing* intrusion and PTS symptoms. People high in disgust sensitivity may have negative appraisals (e.g., distress) about disgust-eliciting events and associated intrusions, which also may ultimately increase risk of *maintaining* intrusion and PTS symptoms (Jones et al., 2020). Future research should elucidate disgust sensitivity's role in negative appraisals of disgust-eliciting events and intrusions.

Our study has several limitations. First, we only measured *recent* event-related disgust (i.e., within 6-months) and intrusion symptoms (i.e., within 1-month), whereas among people with PTSD, there may be longer delays (e.g., years) between a traumatic event and PTS symptom onset (APA, 2022). However, because participants retrospectively reported intrusions, asking about a recent event and associated intrusion symptoms likely facilitated more accurate recollection of these memories—because intrusions are more easily accessible when they are recent (Rubin & Berntsen, 2009; though see Nahleen et al., 2019). Second, because our data are correlational and cross-sectional, we cannot infer causality. The current study is predicated on the assumption that peritraumatic disgust reactions (i.e., at the time of the traumatic event) elicit subsequent intrusion and PTS symptoms. However, current disgust reactions and PTS symptoms (including intrusions) may have biased participants' recollection of their disgust reactions at the time the traumatic event occurred. Although we cannot control for this confound, it is reduced by our focus on *recent* traumatic events, and strong associations between 'then' and 'now' disgust reactions. Nevertheless, future research should capture and compare disgust reactions and intrusion symptoms (e.g., characteristics) in response to disgust and fear trauma experiences in both a longitudinal observational setting and an experimental setting (e.g., randomly allocating participants to view disgust stimuli, fear stimuli, or a control condition). Finally, our sample comprised a general rather than clinical population. However, when we removed participants who had not experienced a HMS event from our main analysis, the findings did not change. Furthermore, the current study provides novel insight as to how intrusions of disgust-eliciting events may be experienced by a general population, beyond intrusion frequency.

Disgust is an important emotion to consider in the development and maintenance of traumatic intrusions and broader PTS symptomatology. Yet, disgust has historically been neglected as a PTSD-relevant emotional reaction in academic literature, clinical practice, and public psychoeducation (Jones et al., 2020). Consequently, people presenting with disgust reactions—and associated intrusion symptoms—following trauma exposure may fall between the cracks in PTSD treatments. Disgust should be explicitly recognised as a relevant negative emotional reaction in PTSD diagnostic manuals. Furthermore, determining psychological treatment approaches that successfully address trauma-related disgust reactions is an important avenue for future research.

Supplementary Materials

Supplementary Table S3.1

Demographics for Participants who Reported at least One Intrusion, n = 261

Gender	
Women	57.5%
Men	41%
Non-binary	0.4%
Prefer not to say	1.2%
Nationality	
American (including "African American", "Native American", "Chinese American" and "European American")	93.1%
Korean	0.4%
Bahamian	0.4%
Indian	0.4%
German	0.4%
Provided ethnicity: "White" and/or "Caucasian"	4.6%
Provided ethnicity: "Asian"	0.8%
Recently experienced a High Magnitude Stressor (Criterion A) event	
Yes	83.5%
No	16.5%
Age	Range: 19-77 years (*M* = 44.4, *SD* = 13.4)

Supplementary Table S3.2

Percentages of THS event types (single event categories), N = 471

THS event	
A: A really bad car, boat, train, or airplane accident	3.2%
B: A really bad accident at work or home	1.7%
C: A hurricane, flood, earthquake, tornado, or fire	3.2%
D: Hit or kicked hard enough to injure	2.5%
E: Forced or made to have sexual contact	1.1%
F: Attack with a gun, knife, or weapon	0.8%
G: During military service – seeing something horrible or being badly scared	0
H: Sudden death of a close family member or friend	32.7%
I: Seeing someone die suddenly or get badly hurt or killed	3.4%
J: Some other sudden event that made you feel very scared, helpless, or horrified	7.2%
K: Sudden move or loss of home and possessions	5.5%
L: Suddenly abandoned by spouse, partner, parent, or family	3%
M: Non-sudden death of a close family member or friend	1.7%
N: Stress or trauma in everyday activities (e.g., financial, occupational, domestic)	9.1%
O: Health-related problems for subject or close other (e.g., illness diagnosis)	7.9%
P: COVID-19 Pandemic-related stressors (e.g., medical, psychological, practical)	12.5%
Q: Relationship issues (e.g., domestic violence without mention of physical abuse)	4.5%

Note. Data collection occurred in December 2020 (during the COVID-19 pandemic) and thus, some participants identified pandemic-related stressors as their worst recent stressful event. Relevant responses are categorised as *P*, which refer to a breadth of pandemic-related stressors other than deaths due to the pandemic (which were categorised either as *H* or *M*, according to participant descriptions). Italicised categories refer to categories that were created/coded from participant descriptions (i.e., not an existing category in the THS).

Supplementary Table S3.3

Percentages of participants who were emotionally bothered (i.e., how long and how much) by their reported most stressful/traumatic recent THS event, *N* = 471

Length of time bothered by their most stressful/traumatic event	
Not at all	3.2%
1 week	13.8%
2-3 weeks	15.9%
A month or more	67.1%
How much emotionally bothered by their most stressful/traumatic event	
Not at all	1.3%
A little	7.2%
Somewhat	16.1%
Much	29.7%
Very Much	45.7%

Supplementary Table S3.4

Percentages of participants who experienced high (> 4) disgust and fear reactions in response to THS event types (single event categories), N = 471

THS event	***n***	***Overall Disgust***	***Physical Disgust***	***Moral Disgust***	***Fear***
A: A really bad car, boat, train, or airplane accident	15	40%	20%	33.3%	53.3%
B: A really bad accident at work or home	8	25%	25%	12.5%	37.5%
C: A hurricane, flood, earthquake, tornado, or fire	15	6.7%	13.3%	0	53.3%
D: Hit or kicked hard enough to injure	12	41.7%	25%	66.7%	50%
E: Forced or made to have sexual contact	5	60%	80%	60%	80%
F: Attack with a gun, knife, or weapon	4	75%	50%	75%	75%
G: During military service – seeing something horrible or being badly scared	0	-	-	-	-
H: Sudden death of a close family member or friend	154	12.3%	8.4%	14.3%	32.5%
I: Seeing someone die suddenly or get badly hurt or killed	16	31.3%	31.3%	12.5%	56.3%
J: Some other sudden event that made you feel very scared, helpless, or horrified	34	44.1%	32.3%	58.8%	67.6%
K: Sudden move or loss of home and possessions	26	23.1%	23.1%	57.7%	50%
L: Suddenly abandoned by spouse, partner, parent, or family	14	42.9%	28.6%	42.9%	42.9%
M: Non-sudden death of a close family member or friend	8	0	0	0	0
N: Stress or trauma in everyday activities	*43*	16.3%	9.3%	16.3%	32.6%
O: Health-related problems for subject or close other	*37*	5.4%	10.8%	5.4%	62.2%
P: COVID-19 Pandemic-related stressors (e.g., medical, psychological, practical)	*59*	16.9%	15.3%	28.8%	44.1%
Q: Relationship issues	*21*	52.4%	23.8%	66.7%	28.6%

Note. Italicised categories refer to categories that were created/coded from participant descriptions (i.e., not an existing category in the THS).

Supplementary Table S3.5

Correlations between 'Then' and 'Now' Ratings for Physical Disgust and Moral Disgust Reactions to a Recent Traumatic Event among All Participants

	r	*p*	95% Confidence Interval
Physical Disgust	.83	< .001	[.80, .86]
Moral Disgust	.89	< .001	[.88, .91]

Note. n = 470 for Physical Disgust; *n* = 471 for Moral Disgust

Supplementary Table S3.6

Correlation Coefficients for Average Disgust (General, Physical, Moral) and Fear Reactions to a Recent Traumatic Event, and Intrusion Characteristics, Intrusion Symptom Severity (PCL-5 Re-experiencing) and Overall PTS Symptoms with 95% Confidence Intervals among All Participants

	General Disgust	Physical Disgust	Moral Disgust	Fear
ICQ Distress	-	.32** [.21, .43]	.32** [.21, .43]	-
ICQ Vividness	-	.11 [-.01, .23]	.13* [.01, .25]	-
ICQ Unwantedness	-	.29** [.18, .40]	.33** [.22, .44]	-
ICQ Nowness	-	.22** [.10, .33]	.19* [.07, .30]	-
ICQ Emotional Intensity	-	.18* [.06, .30]	.20* [.08, .32]	-
ICQ Valence	-	-.26** [-.37, -.14]	-.33** [-.44, -.22]	-
ICQ General Disgust	.87** [.84, .90]	.72** [.66, .77]	.68** [.61, .74]	.35** [.24, .45]
ICQ Physical Disgust	.67** [.60, .73]	.86** [.82, .89]	.48** [.38, .57]	.38** [.27, .48]
ICQ Moral Disgust	.74** [.68, .79]	.55** [.46, .63]	.87** [.83, .89]	.36** [.25, .46]
ICQ Fear	.35** [.24, .45]	.45** [.34, .54]	.31** [.20, .42]	.78** [.73, .82]
PCL-5 Total	-	.51** [.44, .58]	.53** [.46, .59]	-
PCL-5 Re-experiencing	-	.47** [.40, .54]	.43** [.36, .50]	-
PCL-5 Avoidance	-	.33** [.25, .41]	.36** [.28, .44]	-
PCL-5 Negative Alterations in Cognition and Mood	-	.50** [.42, .56]	.54** [.47, .60]	-
PCL-5 Alterations in Arousal and Reactivity	-	.46** [.38, .53]	.48** [.40, .54]	-

Note. * = $p < .05$; ** $p < .001$; ICQ ratings $n = 261$ (except Nowness rating, $n = 260$); PCL-5 ratings $n = 471$; Results where cells are blank are reported in the main paper.

Supplementary Table S3.7

Inferential Statistics from Regression Analyses on Intrusion-Related Physical Disgust Reactions as a Moderator between Traumatic Event-Related Physical Disgust Reactions, and Problematic Intrusion Characteristics and Intrusion Symptom Severity

	Beta	Variance explained (%)	R^2	R^2_{change}	F	F_{change}	*df*	*p*
Problematic Intrusion Characteristics								
1. Event-related physical disgust	.05	14.5	.15		21.82		2, 258	< .001
Intrusion-related physical disgust	.34*							
2. Event-related physical disgust	.12	14.6		.001		0.34	1, 257	.56
Intrusion-related physical disgust	.41*							
Event-related * Intrusion-related physical disgust (interaction)	-.14							
Intrusion Symptom Severity (PCL-5 re-experiencing subscale)								
1. Event-related physical disgust	.44**	24.2	.24		41.15		2, 258	< .001
Intrusion-related physical disgust	.06							
2. Event-related physical disgust	.53**	24.4		.002		0.73	1, 257	.40
Intrusion-related physical disgust	.16							
Event-related * Intrusion-related physical disgust (interaction)	-.19							

Note. * = $p < .05$; ** $p < .001$; $n = 261$

Supplementary Table S3.8

Inferential Statistics from Regression Analyses on Intrusion-Related Moral Disgust Reactions as a Moderator between Traumatic Event-Related Moral Disgust Reactions, and Problematic Intrusion Characteristics and Intrusion Symptom Severity

	Beta	Variance explained (%)	R^2	R^2_{change}	F	F_{change}	df	p
Problematic Intrusion Characteristics								
1. Event-related moral disgust Intrusion-related moral disgust	-.09 .53**	20.6	.21		33.52		2, 258	< .001
2. Event-related moral disgust Intrusion-related moral disgust Event-related * Intrusion-related moral disgust (interaction)	-.20 .41* .23	20.9		.003		0.93	1, 257	.34
Intrusion Symptom Severity (PCL-5 re-experiencing subscale)								
1. Event-related moral disgust Intrusion-related moral disgust	.15 .28*	16.7	.17		25.87		2, 258	< .001
2. Event-related moral disgust Intrusion-related moral disgust Event-related * Intrusion-related moral disgust (interaction)	.27 .41* -.26	17.1		.004		1.10	1, 257	.30

Note. * = $p < .05$; ** $p < .001$; $n = 261$

Supplementary Table S3.9

Inferential Statistics from Regression Analyses on Traumatic Event-Related Physical Disgust Reactions as a Predictor of Problematic Intrusion Characteristics, Intrusion Symptom Severity and PTS Symptoms, after Controlling for Traumatic Event-Related Fear Reactions

	Beta	Variance explained (%)	R^2	R^2_{change}	F	F_{change}	df	p
Problematic Intrusion Characteristics								
1. Fear reactions	.44**	19.0	.19		60.61		1, 259	< .001
2. Fear reactions,	.37**	20.9		.02		6.21	2, 258	.01
Physical Disgust reactions	.15*							
Intrusion Symptom Severity (PCL-5 re-experiencing subscale)								
1. Fear reactions	.48**	23.1	.23		140.53		1, 469	< .001
2. Fear reactions,	.36**	33.6		.11		73.94	2, 468	< .001
Physical Disgust reactions	.35**							
PTS Symptoms (PCL-5 total score)								
1. Fear reactions	.53**	27.5	.28		178.26		1, 469	< .001
2. Fear reactions,	.39**	39.7		.12		94.39	2, 468	< .001
Physical Disgust reactions	.37**							

Note. * = $p < .05$; ** $p < .001$; $n = 261$ for Problematic Intrusion Characteristics; $n = 471$ for Intrusion Symptom Severity and PTS Symptoms

Supplementary Table S3.10

Inferential Statistics from Regression Analyses on Traumatic Event-Related Moral Disgust Reactions as a Predictor of Problematic Intrusion Characteristics, Intrusion Symptom Severity and PTS Symptoms, after Controlling for Traumatic Event-Related Fear Reactions

	Beta	Variance explained (%)	R^2	R^2_{change}	F	F_{change}	df	p
Problematic Intrusion Characteristics								
1. Fear reactions	.44**	19.0	.19		60.61		1, 259	< .001
2. Fear reactions, Moral Disgust reactions	.35**, .24**	24.0		.05		16.95	2, 258	< .001
Intrusion Symptom Severity (PCL-5 re-experiencing subscale)								
1. Fear reactions	.48**	23.1	.23		140.53		1, 469	< .001
2. Fear reactions, Moral Disgust reactions	.38**, .31**	31.3		.08		55.96	2, 468	< .001
PTS Symptoms (PCL-5 total score)								
1. Fear reactions	.53**	27.5	.28		178.26		1, 469	< .001
2. Fear reactions, Moral Disgust reactions	.39**, .39**	41.3		.14		109.30	2, 468	< .001

Note. ** $p < .001$; $n = 261$ for Problematic Intrusion Characteristics; $n = 471$ for Intrusion Symptom Severity and PTS Symptoms

Supplementary Table S3.11

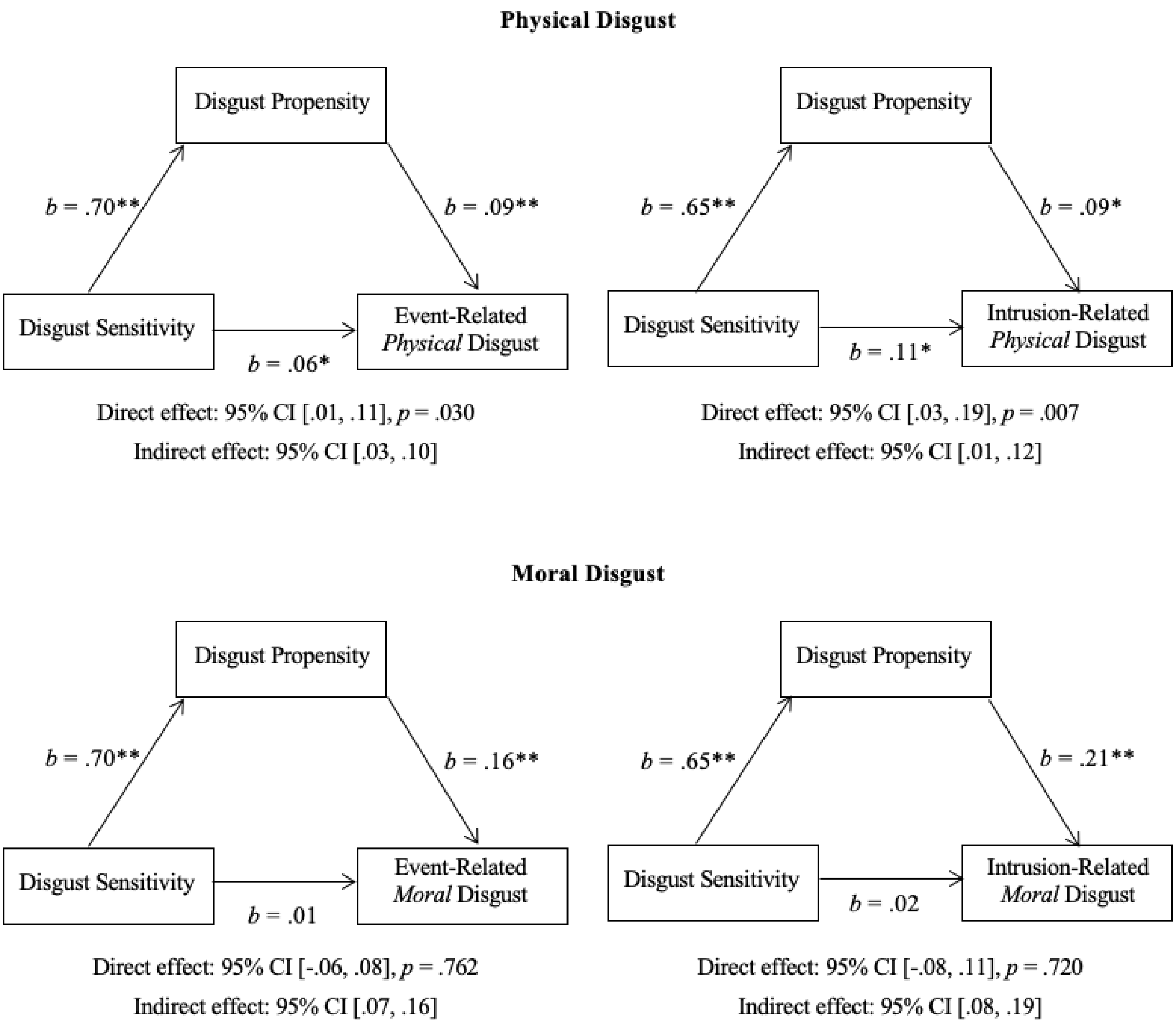
Inferential Statistics from Regression Analyses on Trait Disgust (Disgust Propensity, Disgust Sensitivity, Moral Disgust) as Predictors of Traumatic Event-Related and Intrusion-Related Disgust Reactions (Physical, Moral).

	Beta	Variance explained (%)	R^2	*F*	*df*	*p*
Traumatic Event-Related Physical Disgust						
1. Disgust propensity, Disgust sensitivity Trait moral disgust	.09** .06* -.004	9.7	.10	16.70	3, 467	< .001
Intrusion-Related Physical Disgust						
1. Disgust propensity, Disgust sensitivity Trait moral disgust	.09* .11* -.01	12.2	.12	11.85	3, 257	< .001
Traumatic Event-Related Moral Disgust						
1. Disgust propensity, Disgust sensitivity Trait moral disgust	.16** .01 -.0002	10.2	.10	17.75	3, 467	< .001
Intrusion-Related Moral Disgust						
1. Disgust propensity, Disgust sensitivity Trait moral disgust	.21** .02 .007	12.8	.13	12.55	3, 257	< .001

Note. * = $p < .05$; ** $p < .001$; $n = 471$ for Traumatic Event-Related Disgust Reactions; $n = 261$ for Intrusion-Related Disgust Reactions

Supplementary Figure S3.1

Disgust Propensity as a Mediator of Disgust Sensitivity, and Traumatic Event-Related and Intrusion-Related Disgust Reactions (Physical, Moral) with 95% Confidence Intervals



Note. * = $p < .05$; ** $p < .001$; $n = 471$ for Traumatic Event-Related Disgust Reactions; $n = 261$ for Intrusion-Related Disgust Reactions

Supplementary Table S3.12

Demographics for Participants whose Responses were Indexed to a High Magnitude Stressor Event, n = 322

Gender	
Women	55.6%
Men	43.5%
Non-binary	0
Prefer not to say	0.9%
Nationality	
American (including “African American”, “Native American”, “Chinese American” and “European American”)	93.2%
Korean	0.6%
Chinese	0.3%
Bahamian	0.3%
Malaysian	0.3%
Indian	0.3%
Vietnamese	0.3%
German	0.3%
Provided ethnicity: “White” and/or “Caucasian”	3.7%
Provided ethnicity: “Asian”	0.6%
Age	Range: 19-88 years (M = 43.2, SD = 13.8)

Supplementary Table S3.13

Correlations between 'Then' and 'Now' Ratings for General Disgust and Fear Reactions to a Recent Traumatic Event among Participant Responses Indexed to a High Magnitude Stressor Event

	r	*p*	95% Confidence Interval
General Disgust	.80	< .001	[.75, .83]
Fear	.62	< .001	[.54, .68]

Note. n = 322

Supplementary Table S3.14

Correlation Coefficients for Average General Disgust and Fear Reactions to a Recent Traumatic Event, and Intrusion Characteristics, Intrusion Symptom Severity (PCL-5 Re-experiencing) and Overall PTS Symptoms with 95% Confidence Intervals among Participant Responses Indexed to a High Magnitude Stressor Event.

	General Disgust	Fear
ICQ Distress	.41** [.30, .52]	.48** [.37, .57]
ICQ Vividness	.17* [.04, .30]	.21* [.08, .34]
ICQ Unwantedness	.35** [.23, .46]	.40** [.28, .51]
ICQ Nowness	.25** [.12, .37]	.39** [.27, .49]
ICQ Emotional Intensity	.25** [.12, .37]	.32** [.20, .44]
ICQ Valence	-.37** [-.48, -.25]	-.36** [-.47, -.24]
ICQ General Disgust	.87** [.83, .90]	.44** [.32, .54]
ICQ Physical Disgust	.71** [.63, .77]	.38** [.26, .49]
ICQ Moral Disgust	.75** [.69, .81]	.43** [.31, .53]
ICQ Fear	.44** [.33, .54]	.77** [.71, .82]
PCL-5 Total	.54** [.46, .62]	.54** [.45, .61]
PCL-5 Re-experiencing	.48** [.40, .56]	.50** [.42, .58]
PCL-5 Avoidance	.34** [.24, .44]	.34** [.24, .43]
PCL-5 Negative Alterations in Cognition and Mood	.52** [.44, .60]	.48** [.39, .56]
PCL-5 Alterations in Arousal and Reactivity	.49** [.40, .57]	.51** [.42, .58]

Note. * = $p < .05$; ** $p < .001$; ICQ ratings $n = 218$ (except Nowness rating, $n = 217$); PCL-5 ratings $n = 322$.

Supplementary Table S3.15

Inferential Statistics from Regression Analyses on Intrusion-Related General Disgust Reactions as a Moderator between Traumatic Event-Related General Disgust Reactions, and Problematic Intrusion Characteristics and Intrusion Symptom Severity Intervals among Participant Responses Indexed to a High Magnitude Stressor Event.

	Beta	Variance explained (%)	R^2	R^2_{change}	F	F_{change}	df	p
Problematic Intrusion Characteristics								
1. Event-related general disgust	.05	24.2	.24		34.39		2, 215	< .001
Intrusion-related general disgust	.45**							
2. Event-related general disgust	.17	24.6		.003		0.96	1, 214	.33
Intrusion-related general disgust	-.58*							
Event-related * Intrusion-related general disgust (interaction)	-.26							
Intrusion Symptom Severity (PCL-5 re-experiencing subscale)								
1. Event-related general disgust	.41**	27.0	.27		39.71		2, 215	< .001
Intrusion-related general disgust	.12							
2. Event-related general disgust	.54*	27.3		.003		1.03	1, 214	.31
Intrusion-related general disgust	.26							
Event-related * Intrusion-related general disgust (interaction)	-.26							

Note. * = $p < .05$; ** $p < .001$; $n = 218$

Supplementary Table S3.16

Inferential Statistics from Regression Analyses on Traumatic Event-Related General Disgust Reactions as a Predictor of Problematic Intrusion Characteristics, Intrusion Symptom Severity and PTS Symptoms, after Controlling for Traumatic Event-Related Fear Reactions among Participant Responses Indexed to a High Magnitude Stressor Event

	Beta	Variance explained (%)	R^2	R^2_{change}	F	F_{change}	df	p
Problematic Intrusion Characteristics								
1. Fear reactions	.50**	24.9	.25		71.81		1, 216	< .001
2. Fear reactions,	.39**	29.9		.05		15.32	2, 215	< .001
Disgust reactions	.25**							
Intrusion Symptom Severity (PCL-5 re-experiencing subscale)								
1. Fear reactions	.50**	25.1	.25		107.30		1, 320	< .001
2.Fear reactions,	.36**	34.3		.09		44.59	2, 319	< .001
Disgust reactions	.33**							
PTS Symptoms (PCL-5 total score)								
1. Fear reactions	.54**	28.8	.29		129.41		1, 320	< .001
2. Fear reactions,	.38**	41.3		.13		67.73	2, 319	< .001
Disgust reactions	.39**							

Note. ** $p < .001$; $n = 218$ for Problematic Intrusion Characteristics; $n = 322$ for Intrusion Symptom Severity and PTS Symptoms

Supplementary Table S3.17

Inferential Statistics from Regression Analyses on Trait Disgust (Disgust Propensity, Disgust Sensitivity, Moral Disgust) as Predictors of Traumatic Event-Related and Intrusion-Related General Disgust Reactions among Participant Responses Indexed to a High Magnitude Stressor Event

	Beta	Variance explained (%)	R^2	*F*	*df*	*p*
Traumatic Event-Related General Disgust						
1. Disgust propensity,	.35**	11.4	.11	13.59	3, 318	< .001
Disgust sensitivity	-.07					
Trait moral disgust	-.56					
Intrusion-Related General Disgust						
1. Disgust propensity,	.36**	20.1	.20	17.94	3, 214	< .001
Disgust sensitivity	.12					
Trait moral disgust	-.02					

Note. ** $p < .001$; $n = 322$ for Traumatic Event-Related Disgust Reactions; $n = 218$ for Intrusion-Related Disgust Reactions

Supplementary Table S3.18

Inferential Statistics from Regression Analyses on Traumatic Event-Related Disgust Reactions as a Predictor of Problematic Intrusion Characteristics, Intrusion Symptom Severity and PTS Symptoms, after Controlling for Event-Related Fear Reactions and Gender (Man, Woman).

	Beta	Variance explained (%)	R^2	R^2_{change}	F	F_{change}	df	p
Problematic Intrusion Characteristics								
1. Gender	.14*	2.0	.02		5.19		1, 255	.024
2. Gender,	.09	19.2		.17		54.13	1, 254	< .001
Fear reactions	.42**							
3. Gender,	.11	25.9		.07		23.02	1, 253	< .001
Fear reactions,	.32**							
Disgust reactions	.28**							
Intrusion Symptom Severity (PCL-5 re-experiencing subscale)								
1. Gender	.16**	2.5	.03		11.67		1, 462	< .001
2. Gender,	.09*	23.9		.22		130.20	1, 461	< .001
Fear reactions	.47**							
3. Gender,	.11*	34.7		.11		75.95	1, 460	< .001
Fear reactions,	.34**							
Disgust reactions	.35**							
PTS Symptoms (PCL-5 total score)								
1. Gender	.18**	3.2	.03		15.24		1, 462	< .001
2. Gender,	.11*	28.5		.25		163.53	1, 461	< .001
Fear reactions	.51**							
3. Gender,	.13**	42.9		.14		115.97	1, 460	< .001
Fear reactions,	.36**							
Disgust reactions	.41**							

Note. * $p < .01$; ** $p < .001$; $n = 257$ for Problematic Intrusion Characteristics; $n = 464$ for Intrusion Symptom Severity and PTS Symptoms; 'non-binary' ($n = 3$) and 'prefer not to say' ($n = 4$) gender responses were removed from analyses due to small sample sizes.

Supplementary Table S3.19

Correlation Coefficients for Intrusion Characteristics in the Involuntary Cognitions Questionnaire (ICQ) with 95% Confidence Intervals

	Distress	Vividness	Unwantedness	Nowness	Emotional Intensity	Valence	Retrieval Intent	Retrieval Ease	General Disgust	Physical Disgust	Moral Disgust	Fear
Distress	-	.33** [.21, .43]	.65** [.58, .72]	.39** [.29, .49]	.51** [.42, .60]	-.68** [-.74, -.61]	.08 [-.04, .20]	.48** [.38, .57]	.41** [.31, .51]	.34** [.23, .44]	.40** [.30, .50]	.51** [.42, .60]
Vividness		-	.13* [.01, .25]	.43** [.33, .53]	.60** [.52, .67]	-.10 [-.22, .02]	.24** [.12, .35]	.23** [.11, .34]	.18* [.06, .29]	.12 [-.003, .24]	.13* [.007, .25]	.17* [.05, .29]
Unwantedness			-	.29** [.18, .40]	.19* [.07, .30]	-.71** [-.76, -.64]	.05 [-.07, .17]	.62** [.53, .69]	.38** [.27, .48]	.32** [.21, .43]	.41** [.31, .51]	.50** [.40, .59]
Nowness				-	.53** [.43, .61]	-.18* [-.29, -.06]	.08 [-.05, .19]	.39** [.28, .49]	.26** [.14, .37]	.27** [.16, .38]	.24** [.13, .36]	.38** [.27, .48]
Emotional Intensity					-	-.20* [-.31, -.08]	.17* [.05, .29]	.31** [.20, .42]	.23** [.11, .34]	.22** [.10, .33]	.22** [.10, .33]	.27** [.15, .38]
Valence						-	-.13* [-.25, -.01]	-.47** [-.56, .37]	-.41** [-.51, -.30]	-.28** [-.38, -.16]	-.41** [-.51, -.31]	-.46** [-.55, -.35]
Retrieval Intent							-	.29** [.17, .40]	-.09 [-.21, .04]	-.18* [-.29, -.05]	-.09 [-.21, .03]	-.08 [-.20, .04]
Retrieval Ease								-	.37** [.26, .47]	.28** [.17, .39]	.36** [.25, .46]	.38** [.27, .48]
General Disgust									-	.75** [.69, .80]	.76** [.70, .81]	.44** [.33, .53]
Physical Disgust										-	.59** [.51, .67]	.47** [.37, .56]
Moral Disgust											-	.38** [.27, .48]
Fear												-

Note. * = $p < .05$; ** $p < .001$; n = 261 (except Nowness rating, $n = 260$).

Chapter 4: Investigating Whether Disgust Memory Enhancement Extends to Involuntary Memory

Chapter 4 is submitted for publication, following invited revision:

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Author Contributions: I developed the study design with the guidance of MKTT and EKM. I collected the data, performed the data analysis and interpretation (with assistance from EKM who developed the *R* Script and created the visualisation), and drafted the manuscript. Data from Study 2a was collected as part of my honours study, however the data were re-analysed (using additional analyses, such as mixed effect models) for the current thesis. MKTT and EKM made critical revisions to the manuscript. All authors approved the final version of the manuscript for submission.

Abstract

People remember disgusting stimuli better than fearful stimuli, but do disgust's memory enhancing effects extend to *involuntary* memory? This question is important because disgust reactions occur following trauma, and trauma-related involuntary memories are a hallmark Posttraumatic Stress Disorder (PTSD) symptom. In two experiments, we presented participants (*n* = 88 Study 2a; *n* = 106 Study 2b) with disgust, fear, and neutral images during an attention-monitoring task. Participants then completed an undemanding vigilance task, responding any time an image involuntarily came to mind. We measured the frequency and characteristics of these involuntary memories (e.g., emotional intensity) immediately after encoding and over a 24-hour delay (Study 2b only). Our main findings were mixed: participants experienced similarly frequent (Study 2b)—or more (Study 2a)—disgust as fear involuntary memories. Therefore, when controlling for memory-enhancing confounds (e.g.,

distinctiveness), in-laboratory disgust memory enhancement does not extend to involuntary memory. Disgust memories were more emotionally intense than fear memories over the 24-hour delay—but not immediately after encoding—suggesting disgust elicits additional consolidation processes to fear. Participants paid more attention towards the disgust images, but attention did not account for memory for disgust. In sum, disgust and fear have both similar *and* distinct cognitive effects.

Introduction

We regularly experience disgust, whether by observing moldy food or feeling mistreated. Originally defined as a gustatory response (e.g., vomiting) to ingesting a harmful substance, disgust is also conceptualised as preventing contamination from oneself (e.g., bacteria), or as a reaction to moral violation (e.g., murder). We know people pay more attention to, and—when asked to *voluntarily* retrieve—better remember, disgusting compared to fearful stimuli, despite both emotions being highly negative and arousing (e.g., Moeck et al., 2021). We also know disgust responses occur during and after trauma (Matson et al., 2023). Consequently, people report feeling revulsion and discomfort when they *involuntarily* re-experience a trauma (i.e., via intrusions; Badour & Feldner, 2018); with re-experiencing a hallmark symptom of Posttraumatic Stress Disorder (PTSD; APA, 2022). An interesting possibility then, tested here, is whether people involuntarily retrieve more disgust than fear stimuli.

In general, people remember emotional stimuli—typically measured on arousal and valence (i.e., negative/positive) dimensions—better than neutral stimuli (*emotionally enhanced memory*; Cahill & McGaugh, 1995). But because of differences between discrete emotions (e.g., in physiological responses to disgust and fear), people may also remember them differently (Riegel et al., 2022). Indeed, when closely matched on memory-enhancing characteristics like arousal, valence, distinctiveness (unusual/eye-catching) and/or organization (stimulus set interrelatedness), people voluntarily remember a higher frequency of disgust than fear images; termed *disgust memory enhancement* (Chapman et al., 2013; Chapman, 2018; Moeck et al., 2021; Schienle et al., 2021; West & Mulligan, 2021, Experiment 3).

The prevailing explanation for disgust memory enhancement is that people pay more attention to disgust than fear stimuli, which may lead to better memory encoding (Chapman, 2018; van Hooff et al., 2013). Increased attention toward disgust over fear occurs through two pathways: attentional engagement (i.e., a stimulus captures a person's attention and they experience difficulty disengaging from it) and attentional shift (i.e., a person moves their attention from one location to another; Posner et al., 1987). Studies using a line discrimination task (LDT)—a measure of attentional engagement, where participants look at stimuli whilst indicating the location of a line—find people spend longer looking at disgust than fear stimuli (Chapman et al., 2013; Chapman, 2018; Moeck et al., 2021). Further, eye-tracking studies show people "hyper-scan" disgust stimuli (i.e., quickly shift attention between picture details; like inspecting each piece of mouldy food) but attend to fewer details of fearful and neutral stimuli (e.g., inspect only one marble among a bag of marbles; Fink-Lamotte et al., 2022; Schienle et al., 2021). This attentional bias occurs because disgust stimuli are subtle and pose no imminent danger (e.g., an 'off' smell amongst expired food) whereas fear stimuli elicit urgency to flee the situation (e.g., escaping a predator; Carretié et al., 2011). Therefore, disgust's attentional prioritization over fear stimuli—particularly when cognitive resources are limited, like in the LDT (West & Mulligan, 2021)—functions to maximise benefits (e.g., further explore/analyse the plausibility of contamination) and minimise costs (e.g., avoid dangerous situations).

Despite disgust's robust attentional salience, there is mixed evidence for whether enhanced attention—measured using the LDT—accounts for disgust's enhancement in *memory frequency*. Initial evidence from item analyses[8] showed increased attention toward disgust over fear stimuli fully (Chapman, 2018) or partially (Chapman et al., 2013) accounted for disgust memory enhancement. Notably though, these item analyses were based on 14 observations per image type and thus, likely underpowered. Using mixed effects models with greater statistical power, Moeck et al. (2021) found increased attention toward disgust over fear images did not account for disgust memory enhancement.

To date, research comparing memory frequency for disgust vs. fear has explored voluntary memory. The features of an experience that enhance voluntary memory—like emotional intensity and distinctiveness—also enhance *involuntary* memory (Schlagman & Kvavilashvili, 2008). These similarities arise because the two modes of episodic remembering share basic encoding and maintenance mechanisms (Berntsen, 2010). Thus, if mechanisms underlying enhanced memory for disgust occur at encoding, or during consolidation, people may also show enhanced *involuntary* memory for disgust.

Enhanced involuntary memory for disgust-eliciting stimuli would have clinical implications, since involuntarily re-experiencing trauma is a primary PTSD symptom (APA, 2022). Despite traditional understanding that PTSD symptomatology is predominantly fear-related, trauma exposure can elicit various emotions, including disgust (Badour & Feldner, 2018). Disgust reactions to trauma predict intrusion and other posttraumatic stress (PTS) symptoms, even after controlling for fear reactions (Matson et al., 2023). Further, people's tendency to experience disgust—i.e., the ease and/or frequency of experiencing disgust (propensity), and how negative and/or harmful they perceive disgust experiences (sensitivity; Badour & Feldner, 2018)—are associated with worse PTSD symptoms, making them a potential risk factor for PTSD (Olatunji et al., 2014).

[8] In these item analyses, images were treated as "subjects", meaning the number of datapoints was restricted to the number of images in the study (42).

The Current Studies

We conducted two studies to examine whether people have enhanced *involuntary* memory for disgust-eliciting images relative to fear-eliciting images. We also examined whether disgust involuntary memories would be more emotionally intense than fear involuntary memories, because frequent intrusions are often emotionally intense (Marks et al., 2018). Finally, because of the clinical implications of involuntary memories, we explored whether disgust involuntary memory frequency correlates with disgust propensity/sensitivity and PTS symptoms.

We based our method on Chapman (2018). In each study, participants viewed disgust, fear and neutral images whilst simultaneously completing the LDT to assess attentional engagement. Then, we measured involuntary memories for the images with a monitoring task (Oulton et al., 2018) and over a 24-hour period post-encoding with a diary (Study 2b only). As a secondary interest, we examined whether greater attention towards disgust images contributes to disgust involuntary memory enhancement. We only examined this possibility for memories reported in the monitoring task, because enhanced encoding processes—like attention—do not sufficiently explain the longer-term effects of emotionally enhanced memory (Yonelinas & Ritchey, 2015). Finally, as an exploratory interest, we examined whether involuntarily re-experiencing disgust images correlates with disgust propensity/sensitivity and PTS symptoms. For Study 2b, we normed a new disgust, fear and neutral image set on arousal, valence and distinctiveness using our target population (undergraduates residing in Australia), to address two key limitations from past studies (e.g., Chapman, 2018): (1) the statistical analytic approach used to match image sets was likely underpowered[9] and (2) no image sets were rated on all the aforementioned memory-

[9] A G*Power sensitivity analysis revealed Chapman's (2018) item analysis sample size (*N* = 14 observations per emotion category) was insufficient to detect less than large effect sizes (*d*s < .1.10) with 80% power (at *p* < .05).

enhancing variables. We pre-registered both studies (Study 2a: https://osf.io/qhnd2; Study 2b: https://osf.io/7gv28). Data (Study 2a: https://osf.io/v5wrx; Study 2b: https://osf.io/zj649), analysis code (with relevant data https://osf.io/4sb5d) and supplementary material (https://osf.io/ypzsw) are publicly available. The Flinders University Social and Behavioural Research Ethics Committee approved this research.

Study 2a

Method

Participants

Chapman (2018) found a large within-subjects effect (η_p^2 = .33) for enhanced voluntary memory of disgust, relative to fear and neutral, images. In our study, participants were not instructed to recall as many images as possible. Therefore, we expected a smaller difference than Chapman and based our target n = 78 on an a-priori G*Power analysis using η_p^2 = .06[10] (medium effect), with 80% power (at p <.05) and three measurement-levels. We recruited 94 participants but excluded six for not following instructions during encoding (n = 2) or the monitoring task (n = 4). To ensure analyses for our involuntary memory characteristic measures were appropriately powered, we continued collecting data until 78 participants had ≥1 involuntary memory. Our final sample comprised 88 undergraduates (69 women, 18 men, one non-binary) ranging from 18–39 years (M_{age} = 21.0, SD_{age} = 3.8), with normal/corrected-to-normal vision. Therefore, 88 participants completed the LDT, monitoring task, disgust scales and PCL-5, whereas 78 participants also completed other involuntary memory-related measures. Participants received course credit or $15AUD.

Materials

Images. Stimuli were 14 disgust, 14 fear, and 14 neutral images—sourced and normed by Chapman (2018). Disgust images included injuries/deformity, mould, faeces, and

[10] η_p^2 = .14 was incorrectly entered as a medium effect into our pre-registration (whereas it is a large effect).

non-threatening invertebrate animals. Fear images included threatening animals, disasters-in-progress, and human attacks. Neutral images included common objects and everyday scenes. Chapman matched the disgust and fear images on valence, arousal and organization; the categories differed on disgust and fear ratings in the expected direction. To confirm that our participants (Table 4.1) made similar ratings to Chapman's samples, we ran mixed effect models in *R* (Version 4.3.2) using *lme4/lmerTest* packages (Bates et al., 2015; Kuznetsova et al., 2017) on ratings participants gave at the end of the experiment. In these models, emotion category (disgust, fear) predicted each rating variable and we included random intercepts for participant and image ID[11]. Participants rated the disgust and fear images as similarly arousing, the disgust images as more unpleasant and disgusting than fear images, and the fear images as more frightening than disgust images (Table 4.2).

Table 4.1

Ratings (M [SD]) for Disgust and Fear Images in Study 2a

Rating Type (*scale*)	Disgust	Fear
Arousal (1 = *not at all*, 7 = *highly*)	3.5 (2.0)	3.5 (1.8)
Valence (1 = *extremely unpleasant*, 7 = *extremely pleasant*)	2.1 (1.3)	2.7 (1.2)
Disgust (1 = *not at all disgusting, 7 = extremely disgusting)*	4.8 (2.0)	2.3 (1.7)
Fear (1 = *not at all frightening*, 7 = *extremely frightening*)	3.0 (2.0)	4.0 (2.0)

Note. N = 88

[11] We initially intended to test whether disgust and fear images were matched on arousal and valence, and differed on disgust and fear, via an item analysis (i.e., each image rating averaged across all participants, like Chapman, 2018) but later opted to use mixed effect models. Both analytical approaches yielded the same pattern of results for all image set ratings presented here (see Supplementary Tables S4.1 – S4.3 for results analyzed via item analyses).

Table 4.2

Estimates (With Standard Error and 95% Confidence Intervals) From the Linear Mixed Effects Models for the Comparison Between Disgust and Fear Images on Arousal, Valence, Disgust and Fear Image Ratings in Study 2a

Outcome Variable	*Estimates*	*SE*	*95% CI*	*p*
Arousal	-0.07	0.23	-0.53 – 0.40	.77
Valence	0.58	0.28	0.20 – 0.95	.004
Disgust	-2.49	0.33	-3.17 – -1.81	<.001
Fear	0.98	0.27	0.42 – 1.54	.001

Note. N = 2464 observations; These estimates were obtained with disgust images as the reference category. The estimate therefore represents the difference in rating for fear vs. disgust images.

Line Discrimination Task. As in Chapman (2018), all 42 images appeared in a random order, for 2s each, accompanied by a horizontal white line 0.5cm above or below the image. Participants were instructed to indicate the line's position as quickly as possible via keypress, with slower responses indicating greater attention captured by each image. The image remained visible for the remaining time after the participant's response (e.g., 1500ms for a 500ms response).

Monitoring Task. Participants completed an undemanding, repetitive vigilance task that induces involuntary thoughts (identifying infrequent vertical lines amongst frequent horizontal lines; Schlagman & Kvavilashvili, 2008). Participants indicated each involuntary memory of the images via keypress, which stopped the task and prompted them to complete a page of a thought monitoring booklet before resuming the task. On each page, participants were instructed to *'describe, in a few words, the image that involuntarily came to mind'* and rate the memory on retrieval ease (*'how easily did the image come to mind?'*) and emotional intensity (*'how intense were the emotions you felt when the image came to mind?'*; 1 = *not at all*, 5 = *extremely*). The task ended after 8-min regardless of time spent recording involuntary memories. Two independent raters, one blind to hypotheses, matched descriptions with specific disgust, fear and/or neutral images (interrater reliability: 97.9%) and resolved disagreements together. We calculated involuntary memory frequency per participant by summing the images remembered from each emotion category. We excluded descriptions that did not match any image (0.7%).

Involuntary Cognitions Questionnaire (ICQ). This questionnaire measured global characteristics of involuntary memories experienced during the monitoring task (Oulton et al., 2018). To confirm memories were retrieved involuntarily, we included seven items measuring retrieval ease (e.g., '*The images I viewed earlier came to mind effortlessly*') and intent (e.g., '*I deliberately tried to bring the images I viewed earlier to mind*'; 1 = *not at all accurate*, 7 = *completely accurate*). Five items assessed distress, vividness, unwantedness and emotional intensity (1 = *not at all, 7 = extremely/completely*), and valence (1 = *extremely negative, 7 = extremely positive*). The ICQ is publicly available (https://osf.io/vb589), see Supplementary Table S4.7 for correlations between these involuntary memory characteristics.

Disgust Scales. To encompass physical and moral disgust situations, we used three scales.

The 12-item Disgust Propensity and Sensitivity Scale – Revised (DPSS-R; Fergus & Valentiner; 2009) measures disgust propensity (six items; e.g., *'I avoid disgusting things'*) and disgust sensitivity (six items; e.g., *'When I feel disgusted, I worry that I might pass out'*; *1 = never, 5 = always*). The DPSS-R had good internal consistency (current study: propensity α = .87, sensitivity α = .82).

The 27-item Disgust Scale – Revised (DS-R; Olatunji et al., 2007c) measures disgust sensitivity to various experiences (*'It would bother me tremendously to touch a dead body'*; Items 1-14: 0 = *strongly disagree*, 4 = *strongly agree*; Items 15-27: 0 = *not disgusting at all*, 4 = *extremely disgusting*). The DS-R had good internal consistency (current study: α = .79).

The seven-item Moral Disgust subscale of the Three Domains of Disgust Scale (TDDS; Tybur et al., 2009) measures disgust responses to moral violations (*'Stealing from a neighbour'*; 0 = *not at all disgusting*, 6 = *extremely disgusting*). This subscale had high internal consistency (current study: α = .90).

Posttraumatic Stress Disorder Checklist (PCL-5; Weathers et al., 2013). Participants answered the PCL-5 in relation to their most traumatic/stressful life event. The PCL-5 comprises 20-items, including four subscales measuring key symptom clusters (re-experiencing, avoidance, negative alterations in cognition in mood, alterations in arousal and reactivity). Items (e.g., *'Repeated, disturbing, and unwanted memories of the stressful experience'*) are rated from 1 = *not at all* to 5 = *extremely*. The PCL-5 had high internal consistency herein: α = .94.

Procedure

After providing informed consent, participants completed the LDT. Next, they completed the monitoring task, then those who experienced involuntary memories in this task completed the ICQ. All participants then rated the disgust and fear—and three of the neutral—images on arousal, valence, disgust, and fear (Table 4.1). Because we were only interested in ratings for the disgust and fear images, we included neutral images as an attention check (as expected, we found low disgust, fear and arousal ratings, and intermediate valence ratings; see Supplementary Table S4.3 for descriptive statistics and Supplementary Table S4.4 for inferential statistics). Participants then completed the disgust scales (randomly ordered), PCL-5, and were debriefed.

Results

Preliminary Analyses

We first examined whether participants' memories were *involuntary*, not voluntary. This check was important because the thought-monitoring task instructions (i.e., respond any time an involuntary memory of the images comes to mind) may have generated demand to intentionally retrieve memories of the images, although the simultaneous vigilance task likely reduced demand effects. To confirm participants reported involuntary memories, we first looked at *global* intent and retrieval ease ratings, made in relation to all involuntary memories experienced during the vigilance task. Global intent ratings (M = 3.4, SD = 1.1) were significantly lower than the scale anchor ('7') for intentional retrieval ($t(77)$ = 28.48, p <.001, d = 3.23, 95% CI [2.67, 3.78]). Global retrieval ease ratings (M = 4.9, SD = 1.1) were significantly higher than the scale anchor ('1') for low retrieval ease ($t(76)$ = 37.84, p <.001, d = 4.31, [3.59, 5.02]). These two ratings moderately negatively correlated (r = -.49, p <.001).

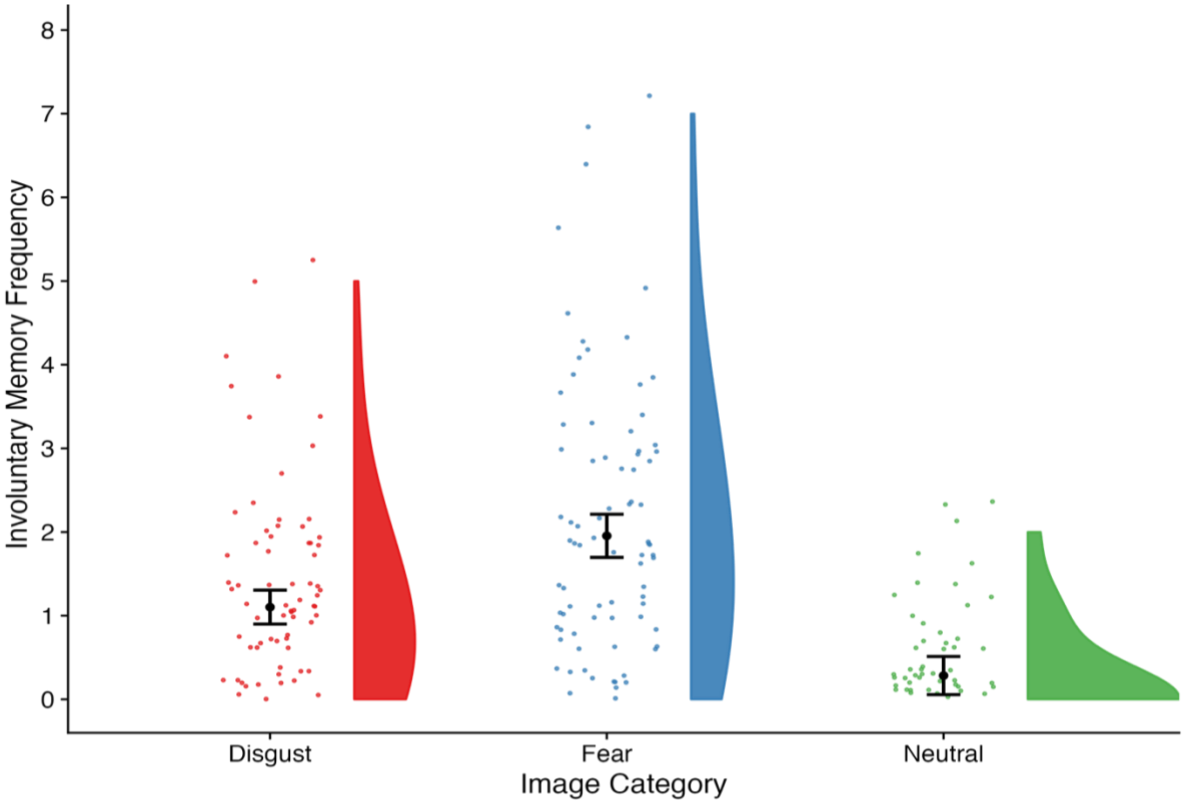
Next, to ensure involuntariness did not differ by emotion category, we calculated each participants' average retrieval ease for disgust, fear, and neutral images separately. A one-way repeated measures ANOVA revealed a significant effect of emotion category ($F(2, 26)$ = 4.18, p = .027, η_p^2 = .24). However, simple contrasts with Bonferroni adjustment (i.e., p <.017, which applies to all simple contrast analyses reported in this paper) revealed no significant difference in retrieval ease between disgust (M = 3.9, SD = 0.7) and fear (M = 3.7, SD = 1.0) memories, M_{diff} = 0.2, p = .27. Furthermore, there were no significant differences in retrieval ease between fear and neutral memories (M = 3.2, SD = 1.3) and disgust and neutral memories; M_{diff} = 0.5, p = .06 and M_{diff} = 0.8 p = .04, respectively. Memories of disgust, fear, and neutral images were similarly involuntary. Thus, the vigilance task induced involuntary memories as expected. Further, when we excluded 24 participants who scored >4 (the scale midpoint) on global intent and/or <4 on global retrieval ease (n = 54 which remains appropriately powered; Brysbaert, 2019), and removed 32 (of 295) individual memories scored <3 on retrieval ease from our main analyses (below), the findings did not change.

Inferential Statistics

Recall our key aim: to determine whether involuntary memory is enhanced for disgust vs. fear images. As Figure 4.1 shows, participants remembered more disgust than fear—and more fear than neutral—images. Simple contrasts revealed statistically significant differences in disgust and fear (M_{diff} = 0.9; 95% CI [0.5, 1.3], p <.001), disgust and neutral (1.7; [1.2, 2.1], p <.001), and fear and neutral (M_{diff} = 0.8; [0.5, 1.1], p <.001) memory frequencies. Indeed, a one-way repeated measures ANOVA revealed a significant effect of emotion category on involuntary memory frequency, $F(2, 174) = 51.73$, p < 001, $\eta_p^2 = .37$. This pattern supports our hypothesis that disgust is enhanced—relative to fear—in *involuntary* memory.

Figure 4.1

Mean Number of Involuntary Memories by Image Emotion Category (Disgust, Fear, Neutral) With 95% Confidence Intervals



Note. N = *88*; The scatterplots on the left represent the raw data and the density plots on the right represent the distribution of involuntary memory frequency. The black dots represent the mean memory frequency (with 95% CI's) for each image emotion category. *M* (*SD*): 2.0 (1.7) for disgust, 1.1 (1.2) for fear, 0.3 (0.6) for neutral.

Next, we examined whether disgust involuntary memories were more emotionally intense than fear involuntary memories. We calculated average emotional intensity by emotion category (disgust, fear, neutral) for each participant. A one-way repeated measures ANOVA revealed a significant effect of emotion category on emotional intensity, $F(2, 26) = 22.42$, $p < .001$, $\eta_p^2 = .63$. Simple contrasts revealed disgust and fear memories were more emotionally intense than neutral memories ($M = 1.1$, $SD = 0.2$), with significant mean differences, p <.001. However, there was no significant difference in emotional intensity for disgust (M = 2.6, SD = 0.9) and fear memories (M = 2.4, SD = 1.0; M_{diff} = 0.2, 95% CI [-0.4, 1.0], p = .25). Thus, participants perceived their disgust and fear involuntary memories as similarly emotionally intense, and more emotionally intense than neutral memories.

Recall our secondary interest in whether attention contributed to disgust memory enhancement. A one-way repeated measures ANOVA on LDT response times[12] revealed a significant effect of emotion category, $F(2, 174) = 28.32$, p <.001, $\eta_p^2 = .25$. Replicating previous studies (e.g., Chapman, 2018), participants paid greater attention (i.e., responded slower, in milliseconds) when the line co-occurred with disgust (M = 653.5, SD = 198.0) compared to fear (M = 614.9, SD = 185.0) and neutral images (M = 593.9, SD = 165.5), with significant mean differences shown by simple contrasts, p <.001. Further, participants showed slower LDT responses when the line co-occurred with fear compared to neutral images, a significant mean difference, p = .016.

To test whether increased attention contributed to enhanced involuntary memories for disgust images, we ran linear mixed effects models in *R*. We used this approach—which differs from the pre-registered approach to collapse attention and memory frequency across *image* (as in Chapman, 2018)—because mixed effect models substantially increase the number of observations, and in turn statistical power, from 42 (the pre-registered by-image approach) to 3696 (mixed effects approach) observations. We aimed to include a random slope for participant and a random intercept for image in all models (Magezi, 2015). However, due to singular fit issues, we often had to simplify the random effects structure to random intercepts only. This simplification did not change any of the findings.

[12] We removed extreme outliers (>3SD per participant) from the analysis. We did not pre-register this exclusion but it matches Chapman et al. (2013) and Chapman (2018).

We first confirmed disgust involuntary memory enhancement replicated using a mixed effect modelling approach. In the first model, emotion category (disgust, fear, neutral) was the predictor and involuntary memory frequency the outcome variable. We set the reference category as disgust to obtain the fixed effect of involuntarily remembering fear and neutral—relative to disgust—images (model equation in Figure 4.2). We re-ran the model with the reference category set to fear to obtain the fixed effect of involuntarily remembering neutral—relative to fear—images. Consistent with our main analysis, participants were more likely to involuntarily remember disgust than fear or neutral images (Table 4.3).

Figure 4.2

Model Equation (Gelman & Hill, 2006) for Testing the Effect of Emotion Category (Disgust [Reference Category], Fear, Neutral) on Involuntary Memory Frequency

$$\begin{aligned}
\mathrm{RecalledTotal}_i &\sim N\left(\alpha_{j[i],k[i]}, \sigma^2\right) \\
\alpha_j &\sim N\left(\mu_{\alpha_j}, \sigma^2_{\alpha_j}\right), \text{ for ID j = } 1, \ldots, \text{J} \\
\alpha_k &\sim N\left(\gamma_0^{\alpha} + \gamma_1^{\alpha}(\mathrm{Imagecat}_{\mathrm{Fear}}) + \gamma_2^{\alpha}(\mathrm{Imagecat}_{\mathrm{Neutral}}), \sigma^2_{\alpha_k}\right), \text{ for Image.ID k = } 1, \ldots, \text{K}
\end{aligned}$$

Table 4.3

Estimates (With Standard Error and 95% Confidence Intervals) From the Linear Mixed Effects Models of Image Emotion Category (Disgust, Fear, Neutral) Predicting Involuntary Memory Frequency in Study 2a

	Recall Frequency			
	Estimates	*SE*	*95% CI*	*p*
Intercept (Disgust)	0.14	0.02	0.10 – 0.18	<.001
Fear (vs. Disgust)	-0.06	0.03	-0.11 – -0.01	.023
Neutral (vs. Disgust)	-0.12	0.03	-0.17 – -0.07	<.001
Neutral (vs. Fear)	-0.06	0.03	-0.11 – -0.01	.028

Note. *N* = 3696 observations. These estimates were obtained from running the model twice with different reference categories. We first ran the model with disgust as the reference category (Rows 1-3). To get the fear vs. neutral comparison, we re-ran the model with fear as the reference category (Row 4).

Then we investigated whether attention contributed to disgust's involuntary memory enhancement. Given our main research interest was enhanced involuntary memory for disgust *relative to fear*, we excluded neutral images from these analyses for interpretation ease. The predictors were emotion category (disgust, fear), attention (LDT response times), and the emotion category x attention interaction (model equation in Figure 4.3). We person-mean centred response times to isolate the within-person effect of attention. The outcome variable was involuntary memory frequency. We ran these models twice—first with disgust set as the reference category and then with fear as the reference category—to obtain the fixed effect of attention on involuntarily remembering images from each emotion category. As Table 4.4 shows, neither emotion category, attention, or the emotion category x attention interaction significantly predicted involuntary memory frequency. Thus, these models revealed attention did not significantly moderate disgust (or fear) involuntary memory frequency.

Figure 4.3

Model Equation (Gelman & Hill, 2006) for Testing the Effect of Emotion Category (Disgust, Fear [Reference Category]), Attention (LDT Response Times), and the Emotion Category x Attention Interaction on Involuntary Memory Frequency

$$
\begin{aligned}
\text{RecalledTotal}_i &\sim N\left(\alpha_{j[i],k[i]}, \sigma^2\right) \\
\alpha_j &\sim N\left(\gamma_0^{\alpha} + \gamma_1^{\alpha}(\text{PC\_LDT}), \sigma^2_{\alpha_j}\right), \text{ for ID j} = 1, \dots, \text{J} \\
\alpha_k &\sim N\left(\gamma_0^{\alpha} + \gamma_1^{\alpha}(\text{Imagecat}_{\text{Disgust}}) + \gamma_2^{\alpha}(\text{Imagecat}_{\text{Disgust}} \times \text{PC\_LDT}), \sigma^2_{\alpha_k}\right), \text{ for Image.ID k} = 1, \dots, \text{K}
\end{aligned}
$$

Table 4.4

Estimates (With 95% CIs) From the Linear Mixed Effects Models of Image Emotion Category (Disgust, Fear), Attention, and Image Emotion Category x Attention Predicting Involuntary Memory Frequency in Study 2a

	Recall Frequency			
Predictors	*Estimates*	*SE*	*95% CI*	*p*
Intercept (Disgust)	0.14	0.02	0.09 – 0.19	**<0.001**
Image category (Fear vs. Disgust)	0.06	0.03	-0.00 – 0.13	.051
Attention slope (Disgust)	0.00	0.00	-0.00 – 0.00	.28
Image category x Attention	0.00	0.00	-0.00 – 0.00	.41
Attention slope (Fear)	0.00	0.00	0.00 – 0.00	.87

Note. N = 2425 observations. Attention (measured by line detection task response times) was person-mean centred. These estimates were obtained from running the model twice with different reference categories. We first ran the model with disgust as the reference category (Rows 1-4). To get the effect of attention on recall frequency for fear, we re-ran the model with fear as the reference category (Row 5).

Next, we ran a mixed effect mediation analysis using the *mediation* package (Tingley et al., 2014). As in Chapman (2018), we tested whether disgust *ratings* (rather than emotion category) predict involuntary memories (the outcome) via attention during encoding (the mediator). This analysis showed (using Quasi-Bayesian 95% confidence intervals and 1000 resamples) that the total effect (b = 0.01, 95% CI [.007, .02], p <.001) was not mediated by attention (indirect effect: b = -0.002, [-.03, .01], p = .65). Thus, whilst participants paid more attention to the disgust images, attention *did not* predict involuntary memory frequency and thus, did not account for disgust's enhancement in involuntary memory.

Finally, we addressed our exploratory aim: whether involuntarily re-experiencing disgust images related to disgust propensity and sensitivity, and PTS symptoms. These results should be interpreted with caution because our sample size is likely too small to detect stable correlations (Schönbrodt & Perugini, 2013; 2018). Disgust memory frequency significantly correlated with scores on the DPSS-R propensity (r(88) = .23, p = .029, 95% CI [.018, .42]) and sensitivity (r(88) = .27, p = .011, [.064, .45]) subscales. These correlations support the idea that people with higher disgust propensity/sensitivity may be prone to experiencing increased intrusive thoughts about disgust stimuli (Bomyea & Amir, 2010). There was no significant correlation between disgust memory frequency and DS-R scores, (r(88) = .11, p = .30, [-.10, .31]) or the TDDS moral disgust subscale (r(88) = -.07, p = .52, [-.28, .14]), perhaps because the items did not match the content of our images (physical/contamination-based disgust). Consistent with research linking PTSD symptomology and disgust responses following trauma (Badour & Feldner., 2018), we found a statistically significant yet small positive correlation between PCL-5 scores and disgust memory frequency (r(88) = .29, p = .006, [.09, .47]), but not fear memory frequency (r(88) = .16, p = .13, [-.05, .36]). These preliminary findings suggest a relationship between disgust involuntary memories and high disgust propensity/sensitivity and PTS symptoms.

Discussion

We aimed to determine whether enhanced voluntary memory for disgust extends to *involuntary* memory. As predicted, participants reported more involuntary memories for disgust—relative to fear and neutral—images. Participants also paid greater attention to the disgust images, but this enhanced attention did not contribute to disgust involuntary memory enhancement. Disgust involuntary memory frequency correlated with higher disgust propensity/sensitivity and PTS symptoms. Our findings align with the discrete emotions perspective that different emotion categories have distinct cognitive effects (Levine & Pizarro, 2004). The memory enhancement pattern we found mirrors existing data on voluntary memory (e.g., Chapman, 2018).

Study 2a has three important limitations. First, counter to Chapman (2018), our participants rated the disgust images as more unpleasant than the fear images, which may have driven disgust memory enhancement. This valence difference could be an artefact of having participants rate image valence shortly after the monitoring phase, such that enhanced involuntary memory for disgust images influenced these ratings. However, additional participants (n = 51) who had never seen the images similarly rated disgust images as more unpleasant (M = 2.1, SD = 0.8) than fear images (M = 2.5, SD = 0.7), $t(50) = -6.12$, p <.001, d = 0.73. Second, the disgust images may have been more memorable due to being more distinctive (unusual/eye-catching) than the fear images, potentially attributable to disgust's subtle cues (Carretié et al., 2011). Distinctive stimuli are prioritised in attention and memory due to their mismatch with prior knowledge/experiences, leaving a strong impression (Murphy et al., 2010). Third, we only measured involuntary memories immediately after encoding. Disgust may elicit additional consolidation processes to fear, promoting disgust's memory advantage after longer delays (Moeck et al., 2021). In line with this idea, Riegel et al. (2022) found greater amygdala activation—which is associated with increased memory consolidation—during encoding for disgust relative to fear words. Further, Chapman et al. (2013) and Moeck et al., (2021) found the effect size for disgust memory enhancement—relative to fear—was larger after a delay (45-min) compared to immediately post-encoding. However, this delay may not have been long enough to reflect emotion consolidation processes on memory (as the effect emotion itself has on memory likely emerges after several hours; Talmi, 2013). We addressed these limitations in Study 2b.

Study 2b

Study 2b aims to examine whether disgust involuntary memory enhancement replicates after better controlling for image-specific confounds (e.g., distinctiveness), and persists following a 24-hour delay (after the occurrence of memory consolidation). To match disgust and fear images on valence, arousal and distinctiveness ratings, and ensure they differed on disgust and fear ratings in the expected direction, we first obtained subjective ratings from a sample of the same population (undergraduates residing in Australia) as Study 2a (cf. existing image norms) in a pilot study. We did not get organization ratings (though see Study 2b Discussion section), but ensured the selected images had unique content for coding ease (e.g., only presenting one image of rotten teeth).

Pilot Ratings Study

We obtained disgust, fear, arousal, pleasantness, and unpleasantness ratings (Table 4.5) for images taken from three sources: Chapman (2018), the Nencki Affective Picture System (NAPS; Marchewka et al., 2014) and Grootswagers et al. (2020). Unlike Chapman (2018), we used two unipolar (rather than one bipolar) valence scales to measure positive (i.e., pleasantness) and negative (i.e., unpleasantness) valence, because these emotional experiences are independent of one another (Kron et al., 2015). In total, 306 undergraduate students (202 women, 47 men, three non-binary) ranging from 18–63 years (M_{age} = 22.3, SD_{age} = 7.7) rated between 23 and 51 images each (from a pool of 157 images), until we had

50 ratings on each dimension per image. We also considered the 28 disgust and fear images used in Study 2a, using existing data from the target population (n = 234 for arousal, disgust and fear ratings). We excluded images rated too high on the alternate emotion (e.g., disgust images rated > 4 on fear) and/or too low on the target emotion (e.g., disgust images rated <4 on disgust), leaving 102 images. Next, a separate group of 54 undergraduate students (38 women, 15 men, one non-binary) ranging from 18–55 years (M_{age} = 21.8, SD_{age} = 5.7) rated 50 images (selected from the 102 eligible images) on distinctiveness. Instructions (following Chapman et al., 2013) were: *Please rate the images on their distinctiveness (i.e., how unusual and eye-catching the images are felt to be)*.

We subsequently selected 14 disgust images (rated high on disgust/low on fear) and 14 fear images (rated high on fear/low on disgust) rated similarly arousing, pleasant, unpleasant, and distinctive (See Appendix E for image codes). We did not increase the number of images relative to Study 2a, because the procedure of matching involuntary memories to specific images via coding descriptions limits the number of images we could include. Specifically, disgust and fear can only be visually portrayed in so many ways (i.e., themes of violence, danger, blood, death and gore). With large groups of images it would be difficult for participants to pinpoint their involuntary memory to a specific image, and to code descriptions to specific images (e.g., "a person with blood" would likely refer to several images in a larger set).

Regarding the neutral images, we considered the 14 neutral images from Study 2a. We had existing data from the target population (ns = 46–47 for arousal, disgust and fear ratings). Using additional participants from the target population, we obtained pleasantness and unpleasantness ratings for these images (n = 50), and disgust, fear, arousal, pleasantness and unpleasantness ratings for an additional nine[13] neutral images taken from Grootswagers

[13] n = 151 as we used these images when piloting different sets of disgust and fear images.

et al. (2020). Because we were primarily interested in distinctiveness as a memory enhancing mechanism for disgust *relative to fear,* we did not obtain distinctiveness ratings for neutral images. We selected 14 neutral images rated low on all dimensions, except intermediate on pleasantness.

Table 4.5 displays descriptive statistics and Table 4.6 displays inferential statistics for disgust and fear image ratings. To test whether disgust and fear images were matched on arousal, valence and distinctiveness, and differed on disgust and fear, we ran the same mixed effect models as for the Study 2a ratings. Participants rated the disgust and fear images as similarly arousing, pleasant, unpleasant, and distinctive. Disgust and fear images differed on disgust and fear, in the expected direction. Disgust, fear, and neutral image sets included the same content categories as Study 2a, as well as dead animals and raw meat for disgust, and frightening faces for fear.

Table 4.5

Ratings (M [SD]) for Disgust and Fear Images in the Study 2b Pilot and Main Study

	Pilot Study		Study 2b	
	Disgust	Fear	Disgust	Fear
Arousal (1 = *not at all arousing*, 7 = *highly arousing*)	3.4 (2.0)	3.6 (1.9)	3.4 (1.9)	3.5 (1.8)
Pleasantness (1 = *not at all pleasant*, 7 = *extremely pleasant*)	1.2 (0.6)	1.3 (0.7)	1.6 (1.0)	1.9 (1.2)
Unpleasantness (1 = *not at all unpleasant*, 7 = *extremely unpleasant*)	5.2 (1.7)	5.0 (1.7)	5.5 (1.5)	4.9 (1.7)
Distinctiveness (1 = *not at all distinctive,* 7 = *extremely distinctive*)	4.5 (1.8)	4.3 (1.8)	4.3 (1.9)	4.1 (1.9)
Disgust (1 = *not at all disgusting,* 7 = *extremely disgusting)*	5.1 (1.9)	3.0 (2.0)	5.0 (1.9)	2.6 (1.9)
Fear (1 = *not at all frightening*, 7 = *extremely frightening*)	3.1 (2.0)	4.6 (1.9)	2.6 (1.8)	3.9 (2.0)

Note. Ns = 50 – 234 per image in the pilot study; *N* = 106 in Study 2b.

Table 4.6

Estimates (With Standard Error and 95% Confidence Intervals) From the Linear Mixed Effects Models for the Comparison Between Disgust and Fear Images on Arousal, Valence, Disgust and Fear Image Ratings in the Study 2b Pilot and Main Study

	Study 2b Pilot Study				
Outcome Variable	*Number of Observations*	*Estimates*	*SE*	*95% CI*	*p*
Arousal	4034	0.30	0.18	-0.06 – 0.67	.098
Pleasantness	2567	0.04	0.07	-0.10 – 0.18	.58
Unpleasantness	2566	-0.24	0.15	-0.56 – 0.08	.13
Distinctiveness	1512	-0.21	0.18	-0.58 – 0.15	.25
Disgust	4034	-1.92	0.25	-2.43 – -1.41	<.001
Fear	4034	1.61	0.20	1.22 – 2.00	<.001
	Study 2b Main Study				
Outcome Variable	*Number of Observations*	*Estimates*	*SE*	*95% CI*	*p*
Arousal	4450	0.11	0.15	-0.18 – 0.40	.45
Pleasantness	4452	0.33	0.10	0.13 – 0.54	.002
Unpleasantness	4452	-0.61	0.16	-0.93 – -0.28	.001
Distinctiveness	4451	-0.15	0.22	-0.60 – 0.30	.49
Disgust	4451	-2.35	0.27	-2.91 – -1.79	<.001
Fear	4452	1.26	0.20	0.87 – 1.66	<.001

Note. These estimates were obtained with disgust images as the reference category.

Main Experiment

Study 2b examined involuntary memory frequency for the disgust, fear and neutral image set we developed in the pilot study. We measured involuntary memories immediately after encoding and over a 24-hour delay. We predicted disgust memory enhancement would replicate for our disgust and fear image sets normed on arousal, valence and distinctiveness, both immediately after encoding and after consolidation (over a 24-hour delay).

Method

Participants. In Study 2a we found a large within-subjects effect (η_p^2 = .37) for enhanced involuntary memory of disgust relative to fear images. Because the difference in involuntary memories for disgust and fear images might be smaller over a delay, we again based our target n = 78 on the same a-priori G*Power analysis as for Study 2a (η_p^2 = .06, 80% power, p <.05, 3 measurement levels). We continued collecting until 78 participants had ≥1 involuntary memory during the 24-hour diary period, because involuntary memories during this period were less frequent than those immediately after encoding. We recruited 113 participants but excluded seven who did not follow instructions (LDT = four, monitoring = one, 24-hour diary period and follow-up online survey = two). Our final sample comprised 106 undergraduates (76 women, 29 men, one non-binary) ranging from 18–39 years (M_{age} = 22.9, SD_{age} = 7.2), with normal/corrected-to-normal vision. All participants completed the LDT, involuntary memory *frequency* measures, disgust scales and PCL-5, whereas 100 participants completed remaining involuntary memory-related measures post-encoding, and 78 participants completed remaining involuntary memory-related measures over the 24-hour delay. Participants received course credit or $20AUD.

Measures.

Images. We first compared image ratings between participants in the pilot study and participants in Study 2b (who rated the images at the end of the study; Tables 4.5 and 4.6). As in the pilot study, disgust and fear images differed on disgust and fear, in the expected direction. Also consistent with the pilot study, participants rated the disgust and fear images as similarly arousing and distinctive. However, unlike the pilot study where we found no significant difference, but consistent with Study 2a's valence findings, participants rated the disgust images as more unpleasant, and less pleasant, than the fear images. As in the pilot study, neutral images were rated as more pleasant, less unpleasant, less arousing, less distinctive, less disgusting, and less frightening than fear and disgust images.

LDT. As in Study 2a (but with our new image set).

Monitoring Task. As in Study 2a. We had similar interrater reliability for description coding (97.3%) and percentage of descriptions not matched to any image (0.8%).

ICQ. As in Study 2a. Supplementary Tables S4.8 and S4.9 display correlations between involuntary memory characteristics.

We included the questionnaires that significantly correlated with disgust memories in Study 2a: the **DPSS-R** (Fergus & Valentiner, 2009; current study: propensity α = .82, sensitivity α = .79) and the **PCL-5** (Weathers et al., 2013; current study: α = .93).

Procedure. During the in-lab component of the study, participants provided informed consent, completed the LDT, then completed the monitoring task (involuntary memories recorded during this task are termed *immediate memories*), followed by the ICQ (only for those who reported involuntary memories). Marking the end of the in-lab component, participants received a thought monitoring diary (containing identical measures as the thought monitoring booklet from the monitoring task) and were instructed to record any involuntary memories they had of the images over the next 24-hours; termed *delay memories*. Next, 24-48 hours (M = 27.7 hours, SD = 7.1 hours) after the in-lab component, participants completed an online survey[14]. First, participants were asked if they experienced involuntary memories over the 24-hours following their in-lab participation and if 'yes', recorded data from their thought monitoring booklet into the survey and completed another ICQ.

[14] Participants were emailed a link to the online survey 24-hours following their participation in the in-lab component (and given a further 24-hour grace period to complete the survey). Most (n = 102) participants completed the survey within 48 hours and the remaining (n = 4) completed the survey within a further 12 hours.

Alternatively, participants could indicate that they did not experience involuntary memories over this period (n = 29) or experienced involuntary memories but forgot to record them in the thought monitoring diary (n = 1); these participants did not complete the ICQ. Next, participants rated the disgust, fear and neutral images on arousal, pleasantness, unpleasantness, distinctiveness, disgust and fear (Table 4.5). We had participants rate the images after the 24-hour delay (rather than within the laboratory session), and all neutral images (rather than a subset like in Study 2a) to gain a complete set of image ratings to compare to our pilot image rating data. Finally, participants completed the DPSS-R and PCL-5 (randomly ordered), and were debriefed.

Results

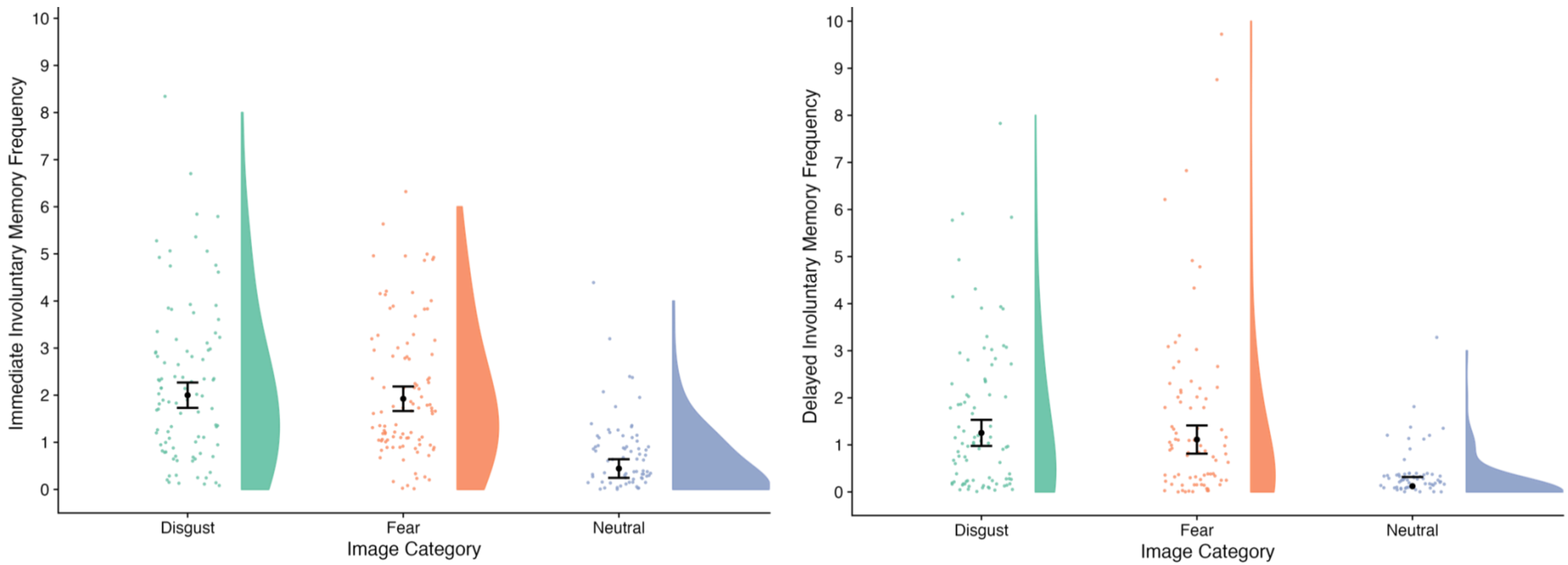
Preliminary Analyses. As in Study 2a, we examined whether participants' memories were *involuntary*. Global intent ratings were significantly lower than the scale anchor ('7') for intentional retrieval for immediate memories (M = 3.0, SD = 1.0; $t(99)$ = 29.69, p <.001, d = 2.97, 95% CI [2.51, 3.42]) and delay memories (M = 2.8, SD = 1.0; $t(74)$ = 23.72, p <.001, d = 2.74, [2.24, 3.23]). Global retrieval ease ratings were significantly higher than the scale anchor ('1') for low retrieval ease for immediate memories (M = 5.1, SD = 1.0; $t(99)$ = 48.62, p <.001, d = 4.86, [4.16, 5.57]) and delay memories (M = 5.0, SD = 1.0; $t(74)$ = 41.74, p <.001, d = 4.82, [4.01, 5.63]). Global intent and retrieval ease ratings moderately negatively correlated for immediate (r = -.42, p <.001, 95% CI [-.57, -.25]) and delay memories (r = -.58, p <.001, [-.71, -.40]).

Next, to ensure involuntariness did not differ by emotion category, we calculated each participants' average retrieval ease for disgust, fear and neutral images separately. A one-way repeated measures ANOVA revealed retrieval ease ratings did not significantly differ by emotion category for immediate memories, $F(2, 66) = 0.64$, p = .53, η_p^2 = .02. Only ten participants reported involuntary memories of neutral images during the 24-hour period (eight reported one, one reported two, one reported three). Therefore, we omit neutral images from our delay memory retrieval ease analysis. Paired samples *t*-tests revealed retrieval ease ratings did not significantly differ between disgust and fear delay memories, $t(31) = 1.15$, $p = .20$, 95% CI [-0.15, 0.52], $d = 0.20$. These findings suggest memories for disgust, fear, and neutral images were similarly involuntary. Further, when we excluded 25 participants who scored >4 (the scale midpoint) on global intent and/or <4 on global retrieval ease ($n = 81$ which remains appropriately powered; Brysbaert, 2019), and removed 71 (of 497) individual memories scored <3 on retrieval ease from our main analysis (below), the findings did not change.

Inferential Statistics. Recall our key aim: to determine whether involuntary memory is enhanced for disgust relative to fear. A one-way repeated measures ANOVAs revealed significant effects of emotion category on involuntary memory frequency ($F(2, 210) = 51.17$, $p < .001$, $\eta_p^2 = .33$ for immediate; $F(2, 208) = 21.98$, $p < .001$, $\eta_p^2 = .17$ for delay). However, as Figure 4.4 shows, participants involuntarily remembered a similar number of disgust and fear images, and fewer neutral images, both immediately after encoding and over the subsequent 24-hours. Simple contrasts revealed no difference in frequency of disgust and fear memories ($M_{diff} = -0.07$, 95% CI [-0.6, 0.4], $p = 1$ for immediate; $M_{diff} = -0.1$, [-0.7, 0.4], $p = 1$ for delay), but statistically significant differences between disgust and neutral memories ($M_{diff} = 1.5$, [1.1, 1.9], $p < .001$ for immediate; $M_{diff} = 1.0$, [0.6, 1.4], $p < .001$ for delay), and fear and neutral memories ($M_{diff} = 1.6$; [1.2, 1.9], $p < .001$ for immediate; $M_{diff} = 1.1$; [0.8, 1.5], $p < .001$ for delay). This pattern does not support our hypothesis, nor does it replicate our Study 2a results that disgust is enhanced—relative to fear—in *involuntary* memory. To assess evidence for the null hypothesis, we ran a Bayesian paired samples *t*-test. According to the ranges Wetzels et al. (2011) describe, we had substantial evidence for the null hypothesis of no difference in recall frequency for disgust and fear involuntary memories ($BF_{10} = 0.11$ for immediate; $BF_{10} = 0.13$ for delay). These findings suggest no difference in involuntary memory frequency when disgust and fear images are normed by the target population and additionally matched on distinctiveness.

Figure 4.4

Mean Number of Involuntary Memories by Image Emotion Category (Disgust, Fear, Neutral) Immediately After Encoding (Left) and Over a 24-Hour Delay (Right) With 95% Confidence Intervals



Note. N = 106; For both graphs, the scatterplots on the left represent the raw data and the density plots on the right represent the distribution of involuntary memory frequency. The black dots represent the mean memory frequency (with 95% CI's) for each image emotion category. Immediate *M* (*SD*): 1.9 (1.5) for disgust, 2.0 (1.7) for fear, 0.4 (0.7) for neutral; Delay *M* (*SD*): 1.1 (1.8) for disgust, 1.3 (1.6) for fear, 0.1 (0.4) for neutral.

Next we examined whether disgust and fear involuntary memories were more emotionally intense than neutral involuntary memories, as in Study 2a. We calculated average emotional intensity by emotion category per participant. A one-way repeated measures ANOVA revealed a significant effect of emotion category on emotional intensity for memories occurring immediately after encoding, $F(2, 66) = 13.73$, $p <.001$, $\eta_p^2 = .29$. Replicating Study 2a, simple contrasts revealed no significant difference in emotional intensity for disgust ($M = 2.3$, $SD = 1.0$) and fear memories ($M = 2.2$, $SD = 0.9$) ($M_{\text{diff}} = 0.1$, 95% CI [-0.4, 0.5], $p = 1$), but disgust and fear memories were more emotionally intense than neutral memories ($M = 1.4$, $SD = 0.7$) with significant mean differences, $p <.001$. We next turn to delay involuntary memories, where we again omit neutral images to maintain power. Paired samples *t*-tests revealed over the 24-hour delay, disgust memories ($M = 2.9$, $SD = 1.2$) were more emotionally intense than fear memories ($M = 2.2$, $SD = 2.2$), $t(31) = 3.27$, $p = .001$, [0.26, 1.12], $d = 1.19$. Taken together, disgust and fear involuntary memories were initially similarly emotionally intense but following memory consolidation, disgust involuntary memories became more emotionally intense (an increase in mean score over time) than fear involuntary memories (mean score remained stable).

Recall our secondary interest in whether attention accounted for disgust memory enhancement. As pre-registered, we removed extreme outliers (response times >3SD from each participant's mean) from the analysis. A one-way repeated measures ANOVA on LDT response times revealed a significant effect of emotion category ($F(2, 210) = 8.43$, $p <.001$, $\eta_p^2 = .07$). Replicating Study 2a's results, participants paid greater attention when the line co-occurred with disgust ($M = 669.6$, $SD = 276.7$) compared to fear ($M = 643.3$, $SD = 265.2$) and neutral images ($M = 643.2$, $SD = 252.9$), with significant mean differences shown by simple contrasts, $p <.001$ and $p = .006$, respectively. Contrary to Study 2a's results, participants showed similar LDT responses when the line co-occurred with fear and neutral images, a non-significant mean difference, p = 1.0.

To test whether increased attention explained enhanced involuntary memories for disgust images, we ran the same linear mixed effect models as Study 2a. We first confirmed our main results replicated using a mixed effects approach. They did: participants were more likely to involuntarily remember disgust and fear images than neutral images, and there was no difference in memory frequency for disgust vs. fear images (Table 4.7). These findings were consistent for immediate and delay memories. This pattern of results remained consistent when we controlled for valence differences by adding pleasantness and unpleasantness ratings as fixed effects in the disgust vs. fear involuntary memory frequency model (see Supplementary Table S4.5). These results also did not change when we removed two image outliers—one disgust and one fear—that produced a higher number of memories (Supplementary Table S4.6).

Table 4.7

Estimates (With Standard Error and 95% Confidence Intervals) From the Linear Mixed Effects Models Predicting Involuntary Memory Frequency From Image Emotion Category (Disgust, Fear, Neutral) Immediately After Encoding and Over a 24-Hour Delay in Study 2b

	Recall Frequency (Immediately after Encoding)			
	Estimates	*SE*	*95% CI*	*p*
Intercept (Disgust)	0.14	0.03	0.08 - 0.19	<.001
Fear (vs. Disgust)	0.01	0.04	-0.07 – 0.08	.89
Neutral (vs. Disgust)	-0.11	0.04	-0.18 – -0.03	.009
Neutral (vs. Fear)	-0.11	0.04	-0.19 – -0.03	.006
	Recall Frequency (Over a 24-hour delay)			
	Estimates	*SE*	*95% CI*	*p*
Intercept (Disgust)	0.08	0.02	0.04 – 0.12	<.001
Fear (vs. Disgust)	0.01	0.03	-0.04 – 0.06	.71
Neutral (vs. Disgust)	-0.07	0.03	-0.12 – -0.02	.012
Neutral (vs. Fear)	-0.08	0.03	-0.13 – -0.03	.004

Note. N = 4452 observations. These estimates were obtained from running each model twice with different reference categories. We first ran the model with disgust as the reference category (Rows 1-3 for each model). To get the fear vs. neutral comparison, we re-ran the model with fear as the reference category (Row 4 for each model).

Then we investigated whether attention contributed to disgust involuntary memory frequency. As Table 4.8 shows, emotion category did not predict involuntary memory frequency, but the emotion category x attention interaction did. This significant interaction was driven by attention predicting memory frequency for *disgust* but not fear. Thus, attention moderated the relationship between disgust and involuntary memory frequency (i.e., this relationship is stronger when people pay more attention to the disgust images). Comparatively, attention did not moderate the relationship between fear and involuntary memory frequency.

Table 4.8

Estimates (With 95% Confidence Intervals) From the Linear Mixed Effects Models of Image Emotion Category (Disgust, Fear), Attention, and Image Emotion Category x Attention Predicting Involuntary Memory Frequency in Study 2b

	Recall Frequency			
	Estimates	*SE*	*95% CI*	*p*
Intercept (Disgust)	0.14	0.03	0.07 – 0.20	<.001
Image category (Fear vs. Disgust)	-0.01	0.05	-0.10 – 0.09	.91
Attention slope (Disgust)	0.00	0.00	-0.00 – 0.00	.026
Image category x Attention	0.00	0.00	0.00-0.00	.020
Attention slope (Fear)	0.00	0.00	-0.00 – 0.00	.275

Note. N = 2809 observations. Attention (measured by line detection task response times) was person-mean centred. These estimates were obtained from running the model twice with different reference categories. We first ran the model with disgust as the reference category (Rows 1-4). To get the effect of attention on recall frequency for fear, we re-ran the model with fear as the reference category (Row 5).

We next ran the same mixed effect mediation analysis as Study 2a, which showed the total effect (b = 0.02, 95% CI [.02, .03], p < .001) was not mediated by attention (indirect effect: b = 0.002, [-.007, .02], p = .54). Whilst participants paid more attention to the disgust images—and enhanced attention increased the likelihood that participants would involuntarily recall those disgust images—attention *did not* account for disgust (or fear) involuntary memory frequency.

Finally, as an exploratory aim, we tested whether involuntary memories related to disgust propensity/sensitivity and PTS symptoms. Unlike Study 2a, disgust memory frequency did not significantly correlate with scores on the propensity ($r(106) = .16$, $p = .11$, 95% CI [-.03, .34] for immediate; $r(105) = .13$, $p = .17$, [-.06, .32] for delay) and sensitivity ($r(106) = .10$, $p = .32$, [-.10, .28] for immediate; $r(105) = .14$, $p = .17$, [-.06, .32] for delay) DPSS-R subscales. We also did not find statistically significant correlations between PCL-5 scores, and disgust memory frequency immediately after encoding ($r(106) = .10$, $p = .33$, [-.10, .28]) or fear memory frequency at both time-points ($r(106) = .06$, $p = .53$, [-.13, .25] for immediate; $r(105) = .15$, $p = .12$, [-.04, .34] for delay). However, we found a statistically significant, small positive correlation between PCL-5 scores and disgust *delayed* memory frequency, $r(105) = .20$, $p = .037$, [.01, .38]. These findings provide additional preliminary evidence for a relationship between enhanced involuntary memories for disgust and higher PTS symptoms. Study 2b suggests this relationship exists after memory consolidation but *not* immediately after encoding.

Discussion

Study 2b determined whether enhanced involuntary memory for disgust—relative to fear—replicated and persisted over a 24-hour delay when images were normed by the target population on valence and arousal, and additionally matched on *distinctiveness*. Contrary to our prediction, we did not replicate the disgust memory advantage: participants reported similarly frequent involuntary memories for disgust and fear images. As expected, participants reported more involuntary memories for disgust and fear images than neutral images, which persisted over a 24-hour delay. Consistent with Study 2a and Moeck et al. (2021), participants paid greater attention to disgust—relative to fear and neutral—images.

Unlike Study 2a, attention moderated the relationship between disgust and involuntary memory frequency. However, consistent with Study 2a, mediation analyses showed that attention ultimately did not account for disgust involuntary memory frequency. Also consistent with Study 2a, participants' *immediate* involuntary memories for disgust and fear images were similarly emotionally intense, and more emotionally intense than neutral images. However, participants' disgust memories were more emotionally intense than fear memories over the 24-hour delay. We also found that disgust involuntary memory frequency during the 24-hour delay correlated with higher PTS symptoms.

Our failure to replicate disgust memory enhancement was unexpected and inconsistent with previous research (Chapman et al., 2013; Chapman, 2018; Moeck et al., 2021). One explanation is that no research to date has matched disgust and fear images on *all* four of the following variables proposed to explain emotional memory enhancement: arousal, valence, distinctiveness and organization. If an image set is not matched on all four variables, we cannot ascertain whether the discrete emotion, or one of these variables, is enhancing memory. In Study 2b, we matched disgust and fear images on the above-mentioned variables excluding *organization*. When an image set has greater organization—or, is more interrelated—a person may recognise thematic links between the images in an emotion category, which ultimately supports some encoding and retrieval processes (Talmi, 2013). For example, a person may link the disgust images depicting rotten teeth and a blood nose into a 'facial feature' category at encoding, whereby remembering one image cues retrieval of a similar image in that category. The same could apply to the fear images (e.g., a gun and bomb categorised as weapons). Therefore, we sought organization ratings for our disgust and fear image sets.

Organization Ratings Study. We presented all possible disgust and fear image pairs (182 pairs total, presented side-by-side in a randomised order) to new undergraduate participants (*n* = 150, where 50 participants each rated 60 or 61 potential image pairs). We asked participants to rate each image pair's relatedness (1 = low relatedness, 7 = high relatedness). Following Chapman (2018) and Talmi et al., (2007a), we asked participants to ignore superficial similarities (e.g., colour, layout) between image pairs and provided three examples of how images can be related: part of the same category (e.g., a chair and a table are both an example of furniture); thematically related (e.g., rain and an umbrella); or, because one item in the image brings to mind another item in the other image (e.g., a bow brings to mind an arrow).

To test whether disgust and fear images were matched on organization, we tested whether image category (disgust, fear) predicted image relatedness ratings (which participants gave for each image pair) in a linear mixed effect model[15]. Participants rated the fear images (M = 3.6, SD = 2.1) as significantly more interrelated than the disgust images (M = 3.1, SD = 1.9; Est. = 0.45, SE = 0.20, 95% CI [0.06 – 0.83], p = .02). Although both image sets were moderately interrelated (below the midpoint), the disgust and fear images were not matched on organization. The conceptual similarities within the fear image set—relative to disgust images—may explain why we did not replicate the disgust memory advantage for involuntary memories in Study 2b. Whilst attention influences a person's ability to cognitively organise stimuli (Talmi et al., 2007b), interrelatedness (i.e., organization) does not influence attention. Indeed, despite disgust images being rated lower on organization, we found a disgust attention advantage (i.e., people paid more attention to disgust than fear images). We also found a disgust memory phenomenology advantage (i.e., people's involuntary memories of disgust images grew in emotional intensity over time, whereas their memories of fear images did not). Thus, it seems unlikely that interrelatedness influences

[15] We found the same pattern of results using an item analysis approach (as used by Chapman, 2018); these data are reported in Supplementary Table S4.2

memory phenomenology. Based on these findings, we postulate that the emotion itself (e.g., disgust) influences memory more than the interrelatedness of the image set. However, we know that interrelatedness enhances recall, likely because retrieving one image cues retrieval of another image (Talmi, 2013). In line with this idea, when Chapman (2018) *equated* disgust and fear image sets on organization, they found participants remembered more disgust than fear images. Involuntary memory frequency is the only variable we measured that is likely influenced by interrelatedness and the only variable we did not observe a disgust advantage for, perhaps because the high interrelatedness among fear images provided a competing memory advantage. Thus, perhaps if the disgust and fear images had been matched on organization, we would also have observed disgust memory enhancement in involuntary recall, though future research is needed to confirm this proposition.

Notably though—whilst from the same target population—these participants were not those from Study 2b. Thus, we cannot definitively conclude that participants in the main experiment perceived the fear images as more interrelated than the disgust images. Indeed, other variables within our normed image set (e.g., unpleasantness) were not consistently matched from our pilot study sample to our main study sample, despite these samples being from the same target population.

General Discussion

We aimed to determine whether disgust voluntary memory enhancement extends to *involuntary* memory at two time-points—immediately post-encoding and over a 24-hour delay. Our main findings were mixed: participants reported more involuntary memories for disgust—relative to fear—images in Study 2a (measured immediately post-encoding) but similar involuntary memory frequencies for disgust as fear in Study 2b (measured immediately and 24-hours post-encoding). In line with emotionally enhanced memory (Cahill & McGaugh, 1995), participants consistently reported more involuntary memories for disgust and fear—relative to neutral—images. Participants paid greater attention to the disgust images, but attention did not account for disgust involuntary memory frequency. Participants consistently rated their disgust and fear memories as similarly emotionally intense immediately post-encoding. However, disgust memories became more emotionally intense, whereas fear involuntary memories stagnated in intensity, after memory consolidation (over a 24-hour delay). Finally, we found mixed evidence for a relationship between disgust involuntary memory frequency, and higher disgust propensity/sensitivity and PTS symptoms.

Our mixed main findings do not support a robust disgust involuntary memory enhancement effect. We eliminated disgust memory enhancement when using disgust and fear images normed by our target population on arousal, distinctiveness, and valence. Therefore, it is plausible that disgust and fear stimuli are similarly memorable, which both traditional null hypothesis significance testing and Bayesian analyses confirmed in Study 2b. When disgust and fear memory frequency differences do exist, these are likely driven by real-world pre-existing differences between disgust and fear stimuli on arousal, valence, and distinctiveness. Indeed, experimentally matching disgust and fear images reduces the ecological validity of our findings (e.g., if disgust experiences are inherently more unpleasant and distinctive than fear experiences, disgust may then be more memorable than fear in real-world situations).

Disgust's attentional salience—relative to fear—was robustly supported in our experiments and by existing research (e.g., van Hooff et al., 2013). However, increased attention towards disgust images did not account for disgust memory enhancement. Consistent with Moeck et al. (2021), this finding provides compelling evidence that with a more robust analytic approach, attention *does not* explain enhanced memory for disgust. Our attention findings are in line with other research suggesting attention does not account for enhanced memory of negative emotions (Talmi et al., 2007b). A potential explanation for disgust's attentional salience—yet lack of memory enhancement—is that disgust leads to attentional rubbernecking (Fink-Lamotte et al., 2022). In other words, people may be drawn to disgusting stimuli—and struggle to look away—yet engage in cognitive avoidance by not processing the stimuli in-depth. However, this possibility is unlikely because attention moderated the relationship between disgust and involuntary memory frequency in Study 2b (i.e., participants were more likely to involuntarily recall the disgust images they spent longer attending to during encoding).

Turning to our delayed memory findings, our emotional vs. neutral findings were consistent with consolidation models (Talmi, 2013), whereby people better remember negative images (disgust and fear) than neutral images over a 24-hour delay. Furthermore, we found some support for different disgust and fear memory consolidation processes. Though people experienced similarly frequent disgust and fear involuntary memories over the 24-hour delay, their disgust involuntary memories became more emotionally intense over time (relative to fear). These results support the proposition that disgust elicits additional consolidation processes to fear (Moeck et al., 2021; Riegel et al., 2022), demonstrated here by heightened emotional intensity—but not frequency—after a delay. These findings should be replicated before robust conclusions can be made about the differential consolidation of disgust and fear memories.

Whilst disgust and fear were remembered at a similar frequency, disgust images were more attention-grabbing and emotionally intense than the fear images, consistent with the idea that discrete emotions have distinct cognitive (e.g., attention and memory) effects (Chapman, 2018). Appraisal theorists who consider a discrete perspective of emotion (e.g., Levine & Pizarro, 2004) predict that people attend to—and subsequently remember—information related to the function of the emotion they predominantly experienced. For example, when frightened, people are more likely to remember threat-related information (e.g., remembering the weapon after witnessing a crime) and when disgusted, people are more likely to remember repulsion-related information (e.g., remembering a deceased body after witnessing a fatal car crash; Dalgleish & Power, 2004; Levine & Edelstein, 2009). However, traditional discrete perspectives of emotion (e.g., basic emotion theory; Ekman, 1992) do not provide well-specified predictions for whether certain emotions (e.g., disgust) are consistently more memorable than other emotions (e.g., fear). Notably though, academics in this field have called for future research to examine how different emotions may differentially influence cognitive processes (e.g., attention, memory; Ortony, 2021). Our results show—in line with other studies (Chapman, 2018; Moeck et al., 2021)—that different emotions can differentially influence cognitive processes. In terms of attention, we found that people attend to disgust longer than fear, suggesting disgust reliably captures and holds attention more than fear. In terms of memory, we explored—for the first time—involuntary memories for disgust vs. fear. Taking our findings alongside prior work exploring voluntary memory (Chapman et al., 2013; Schienle et al., 2021), it seems that disgust is voluntarily recalled more than fear, but that disgust memory enhancement does not extend to involuntary memories. However, we did find evidence of differences in involuntary memory characteristics; people rated memories of disgust images as more emotionally intense over time than memories of fear images. Thus, our results extend discrete perspectives of emotion by showing that cognitive differences (for attention and sometimes for memory) exist between disgust and fear (beyond merely remembering information related to the function of these emotions).

One explanation for these cognitive differences is that disgusting images are processed differently to fear images. Darwin (1965/1872) defined disgust as a response to “revolting” substances that are either *perceived* or *vividly imagined*. Therefore, unrealistic and non-threatening disgust stimuli (i.e., images) may nevertheless elicit intense emotional responses, potentially contributing towards disgust's enhancement in attention and memory characteristics (i.e., emotional intensity) after memory consolidation. By contrast, fear responses generally occur in relation to an *imminent*, *perceived* threat (Carretié et al., 2011). Viewing images encompassing fearful situations (but *not* real perceived threat) may not elicit the emotional intensity of a real-life fear-inducing event. Indeed, the disgust images yielded greater disgust ratings than the fear images yielded fear ratings. Nevertheless, using a set of normed images as stimuli offers a high degree of experimental control. Additionally, understanding how people attend to—and involuntarily remember—disgust images is important in occupations (i.e., law enforcement investigators) that involve repeated exposure to disturbing images, which may result in negative reactions (e.g., distress) and developing secondary traumatic stress disorder (Perez et al., 2010).

Our findings also have clinical implications. Existing research showing a relationship between disgust involuntary memories and PTS symptoms suggests a link between persistent intrusions of disgust-eliciting traumatic events and adverse clinical outcomes (e.g., PTSD; Badour & Feldner, 2018). In the present study, participants experienced similarly frequent disgust and fear involuntary memories, aligning with existing literature demonstrating disgust's association with intrusion and PTS symptoms is comparable to fear (Matson et al., 2023). Notably, participants' disgust memories were more emotionally intense than fear memories following memory consolidation. This finding is clinically relevant because emotionally intense and distressing memories of a traumatic event increase a person's risk of developing and maintaining future PTS symptoms (Marks et al., 2018). We also found preliminary evidence of positive correlations between PTS symptoms and immediate (Study 2a) and delayed (Study 2b) involuntary memories for disgust. However, these findings were mixed—we did not replicate the correlation between PTS symptoms and immediate memories for disgust in Study 2b—and likely underpowered. Nevertheless, at present, disgust reactions are inadequately targeted in some PTSD treatments (e.g., exposure therapy) that effectively target fear responses (Badour & Feldner, 2018). This finding, taken alongside our findings, highlights the need to further study how PTSD treatments can be adapted to better target disgust (as has been done for other clinical disorders, such as Obsessive-Compulsive Disorder; Fink-Lamotte et al., 2018).

Our research has limitations. First, despite comprehensive pilot testing, the disgust and fear images were not matched on valence in Study 2b: disgust images were rated less pleasant, and more unpleasant, than fear images. However, these differences were small (0.6 mean difference) and likely reflect a real-world difference in disgust vs. fear 'unpleasantness'. Furthermore, organization ratings from an additional sample (the same target population) showed fear images were rated as more interrelated than disgust images. However, these differences were also small (0.5 mean difference), and ultimately participants were not the same as Study 2b. Second, our attention measure did not capture where participants were looking (e.g., via eye-tracking), although we instructed participants to pay attention to the images.

Challenging the seemingly robust disgust memory advantage, the present study found that when disgust and fear images are well-matched, disgust involuntary memories occur at a similar frequency to fear involuntary memories. But relative to fear, disgust was more attentionally salient and disgust involuntary memories became more emotionally intense over time. Thus, our findings suggest disgust and fear are different emotional categories with some similar and distinctive cognitive effects. Continuing to investigate similarities and differences between disgust and fear involuntary memories is important because prolonged disgust reactions—like fear reactions—may develop into clinical and subclinical PTSD.

Supplementary Materials

Supplementary Table S4.1

Descriptive (Ms and [SDs]) and inferential statistics (independent samples t-tests) for the comparison between disgust and fear image ratings in Study 2a, using the item analysis approach.

	Disgust Images	Fear Images					
	M (*SD*)	*M* (*SD*)	*df*	*t*	*p*	95% CI	Cohen's *d*
Arousal	3.5 (0.7)	3.5 (0.5)	26	0.30	.77	-0.40 – 0.53	0.11
Valence	2.1 (0.5)	2.7 (0.5)	26	-3.21	.004	-0.94 – -0.21	1.21
Disgust	4.8 (0.9)	2.3 (0.8)	26	7.81	<.001	1.83 – 3.14	2.95
Fear	3.0 (0.7)	4.0 (0.6)	26	-3.78	<.001	-1.51 – -0.45	1.43

Note. $N = 14$ per emotion image category.

Supplementary Table S4.2

Descriptive (Ms and [SDs]) and inferential statistics (independent samples t-tests) for the comparison between disgust and fear image ratings in Study 2b, using the item analysis approach.

	Study 2b Pilot Study						
	Disgust Images	Fear Images					
	M (*SD*)	*M* (*SD*)	*df*	*t*	*p*	95% CI	Cohen's *d*
Arousal	3.2 (0.6)	3.5 (0.3)	26	-1.45	.16	-0.60 – 0.10	0.55
Pleasantness	1.5 (0.4)	1.4 (0.4)	26	0.42	.68	-0.25 – 0.38	0.16
Unpleasantness	5.2 (0.4)	5.0 (0.3)	26	1.37	.18	-0.10 – 0.49	0.52
Distinctiveness	4.5 (0.4)	4.3 (0.2)	26	1.73	.095	-0.04 – 0.47	0.65
Disgust	5.0 (0.7)	3.1 (0.6)	26	7.92	<.001	1.42 – 2.42	2.99
Fear	3.0 (0.6)	4.6 (0.4)	26	-8.89	<.001	-2.01 – -1.26	3.36
	Study 2b Main Study						
	Disgust Images	Fear Images					
	M (*SD*)	*M* (*SD*)	*df*	*t*	*p*	95% CI	Cohen's *d*
Arousal	3.4 (0.4)	3.5 (0.3)	26	-0.80	.43	-0.35 – 0.15	0.30
Pleasantness	1.6 (0.2)	1.9 (0.3)	26	-3.64	.001	-0.52 – -0.15	1.38
Unpleasantness	5.5 (0.4)	4.9 (0.4)	26	4.21	<.001	0.31 – 0.91	1.59
Distinctiveness	4.3 (0.4)	4.1 (0.6)	26	0.78	.44	-0.26 – 0.58	0.30
Disgust	5.0 (0.7)	2.6 (0.6)	26	9.20	<.001	1.82 – 2.88	3.48
Fear	2.6 (0.4)	3.8 (0.5)	26	-7.51	<.001	-1.59 – -0.91	2.84
Organization	3.1 (0.3)	3.6 (0.6)	26	-2.51	.019	-0.81 – -0.08	0.95

Note. N = 14 images per emotion category.

Supplementary Table S4.3

Descriptive statistics (Ms and [SDs]) for neutral image ratings in all studies, using the item analysis approach.

Rating Type	Study 2a	Study 2b (Pilot Study)	Study 2b (Main Study)
Arousal	1.9 (0.5)	1.8 (0.3)	1.6 (0.2)
Valence	5.4 (0.7)	-	-
Pleasantness	-	4.2 (0.5)	4.4 (0.5)
Unpleasantness	-	1.6 (0.3)	1.6 (0.2)
Distinctiveness	-	-	2.0 (0.5)
Disgust	1.1 (0.2)	1.2 (0.1)	1.1 (0.04)
Fear	1.2 (0.3)	1.2 (0.2)	1.1 (0.1)

Note. N = 14 images. Consistent with Chapman (2018), we measured valence using a bipolar scale in Study 2a. However, in Study 2b, we used two unipolar valence scales to measure positive (i.e., pleasantness) and negative (i.e., unpleasantness) valence, because these emotional experiences are independent of one another (Kron et al., 2015).

Supplementary Table S4.4

Estimates (with Standard Error and 95% Confidence Intervals) from the linear mixed effects models comparing arousal, valence, disgust and fear ratings for neutral vs. disgust and fear images in Study 2b.

	Study 2b Main Study				
Rating Variable	*Emotion category comparison*	*Estimates*	*SE*	*95% CI*	*p*
Arousal	Neutral vs. Disgust	1.79	0.16	1.47 – 2.11	<.001
	Neutral vs. Fear	1.90	0.16	1.59 – 2.21	<.001
Pleasantness	Neutral vs. Disgust	-2.87	0.18	-3.22 – -2.51	<.001
	Neutral vs. Fear	-2.53	0.17	-2.88 – -2.19	<.001
Unpleasantness	Neutral vs. Disgust	3.89	0.15	3.58 – 4.20	<.001
	Neutral vs. Fear	3.28	0.16	2.96 – 3.61	<.001
Distinctiveness	Neutral vs. Disgust	2.29	0.20	1.89 – 2.69	<.001
	Neutral vs. Fear	2.14	0.20	1.73 – 2.54	<.001
Disgust	Neutral vs. Disgust	3.94	0.21	3.51 – 4.36	<.001
	Neutral vs. Fear	1.59	0.21	1.16 – 2.01	<.001
Fear	Neutral vs. Disgust	1.47	0.14	1.19 – 1.76	<.001
	Neutral vs. Fear	2.74	0.14	2.45 – 3.02	<.001

Note. N = 4452 observations (except n = 4450 observations for Arousal and n = 4451 observations for Distinctiveness and Disgust, due to missing data). We ran one model per rating type and set neutral images as the reference category. We did not run these same analyses on the Study 2a and Study 2b Pilot Study data, because not all participants rated the same images in those experiments.

Supplementary Table S4.5

Estimates (with Standard Error and 95% Confidence Intervals) from the linear mixed effects models of image emotion category (disgust, fear) predicting involuntary memory frequency with image pleasantness and unpleasantness ratings included as fixed effects in Study 2b.

	Recall Frequency (Immediately after Encoding)			
	Estimates	*SE*	*95% CI*	*p*
Intercept (Disgust)	0.00	0.05	-0.09 – 0.10	.93
Image category (Fear vs. Disgust)	0.03	0.04	-0.06 – 0.12	.53
Pleasantness	-0.02	0.00	-0.03 – -0.00	.03
Unpleasantness	0.03	0.00	0.02 – 0.04	<.001
	Recall Frequency (Over a 24-hour delay)			
Intercept (Disgust)	-0.06	0.04	-0.15 – 0.02	.13
Image category (Fear vs. Disgust)	0.03	0.03	-0.04 – 0.09	.36
Pleasantness	-0.01	0.00	-0.02 – 0.01	.32
Unpleasantness	0.03	0.00	0.02 – 0.04	<.001

Note. N = 2968 observations.

Supplementary Table S4.6

Estimates (with Standard Error and 95% Confidence Intervals) from the linear mixed effects models predicting involuntary memory frequency from image emotion category (disgust, fear, neutral) in Study 2b, with two images (one disgust, one fear) that produced an irregularly high number of involuntary memories (i.e., outliers) removed.

	Recall Frequency (Immediately after Encoding)			
Emotion	*Estimates*	*SE*	*95% CI*	*p*
Intercept (Disgust)	0.11	0.02	0.08 – 0.15	< .001
Fear (vs. Disgust)	-0.00	0.02	-0.05 – 0.04	.95
Neutral (vs. Disgust)	-0.08	0.02	-0.13 – -0.04	.001
Neutral (vs. Fear)	-0.08	0.02	-0.13 – -0.03	.001
	Recall Frequency (Over a 24-hour delay)			
Emotion	*Estimates*	*SE*	*95% CI*	*p*
Intercept (Disgust)	0.07	0.01	0.04 – 0.09	< .001
Fear (vs. Disgust)	-0.00	0.02	-0.04 – 0.03	.83
Neutral (vs. Disgust)	-0.06	0.02	-0.09 – -0.03	.001
Neutral (vs. Fear)	-0.06	0.02	-0.09 – -0.02	.001

Note. N = 4240 observations. These estimates were obtained from running each model twice with different reference categories. We first ran the model with disgust as the reference category (Rows 1-3 for each model). To get the fear vs. neutral comparison, we re-ran the model with fear as the reference category (Row 4 for each model).

Supplementary Table S4.7

Study 2a Correlation Coefficients for Involuntary Memory Global Characteristic Ratings with 95% Confidence Intervals.

	Global Distress	Global Vividness	Global Unwantedness	Global Valence	Global Emotional Intensity	Global Retrieval Ease	Global Intent
Total Memory Frequency	.13 [-.09, .35]	.22 [-.004, .42]	.14 [-.08, .35]	-.22* [-.001, -.43]	.18 [-.04, .39]	.09 [-.14, .31]	-.09 [-.31, .14]
DPSS-R Disgust Propensity Subscale	.54** [.35, .68]	.07 [-.15, .29]	.45** [.25, .61]	-.65** [-.77, -.51]	.47** [.28, .63]	-.004 [-.23, .22]	-.19 [-.40, .03]
DPSS-R Disgust Sensitivity Subscale	.60** [.43, .72]	.14 [-.08, .35]	.43** [.23, .60]	-.50** [-.65, -.32]	.59** [.42, .72]	.02 [-.21, .24]	-.06 [-.27, .17]
DS-R	.51** [.32, .66]	.05 [-.17, .27]	.35* [.13, .53]	-.39* [-.56, -.18]	.45** [.26, .61]	.03 [-.19, .26]	-.16 [-.37, .06]
TDDS Moral Disgust Subscale	.006 [-.22, .23]	.009 [-.21, .23]	.06 [-.17, .28]	-.06 [-.28, .16]	-.008 [-.23, .22]	.05 [-.18, .27]	.07 [-.16, .29]
Global Intent	-.13 [-.34, .10]	-.12 [-.33, .11]	-.40** [-.57, -.19]	.36* [.15, .54]	-.29* [-.48, -.07]	-.49** [-.64, -.30]	-
Global Retrieval Ease	-.03 [-.25, .20]	.40** [.20, .58]	.09 [-.14, .31]	-.24* [-.02, -.44]	.10 [-.12, .32]	-	
Global Emotional Intensity	.78** [.67, .85]	.26 [.04, .46]	.73** [.61, .82]	-.54** [-.68, -.36]	-		
Global Valence	-.65** [-.76, -.50]	-.26 [-.45, -.03]	-.53** [-.68, -.35]	-			
Global Unwantedness	.71** [.58, .81]	.14 [-.08, .36]	-				
Global Vividness	.21 [-.009, .42]	-					

Note. * = $p < .025$; ** = $p < .001$; $N = 78$; DPSS-R: Disgust Propensity and Sensitivity Scale – Revised; DS-R: Disgust Scale – Revised; Bonferroni adjusted for 'problematic' memory characteristics (distress, vividness, unwantedness, valence and emotional intensity; $p < .01$) and 'involuntary' memory characteristics (retrieval ease and intent; $p < .025$).

Supplementary Table S4.8

Study 2b Correlation Coefficients for Involuntary Memory Global Characteristic Ratings (immediately post-encoding) with 95 Confidence Intervals.

	Global Distress	Global Vividness	Global Unwantedness	Global Valence	Global Emotional Intensity	Global Retrieval Ease	Global Intent
Total Memory Frequency	.11 [-.09, .30]	.15 [-.05, .33]	-.08 [-.27, .12]	-.001 [-.20, .20]	.07 [-.13, .26]	.02 [-.17, .22]	-.11 [-.30, .09]
DPSS-R Disgust Propensity Subscale	.36** [.18, .52]	-.03 [-.22, .17]	.08 [-.12, .28]	-.34** [-.50, -.15]	.34** [.15, .50]	.03 [-.17, .22]	-.10 [-.29, .10]
DPSS-R Disgust Sensitivity Subscale	.32* [.14, .49]	-.02 [-.22, .18]	.22 [.03, .40]	-.47** [-.61, -.30]	.44** [.26, .58]	-.06 [-.26, .13]	-.06 [-.25, .14]
Global Intent	-.16 [-.34, .04]	-.39** [-.55, -.21]	-.38** [-.53, -.19]	.05 [-.15, .24]	-.28* [-.45, -.09]	-.42** [-.57, -.25]	-
Global Retrieval Ease	.08 [-.12, .27]	.51** [.35, .64]	.09 [-.11, .28]	-.08 [-.28, .11]	.19 [-.008, .37]	-	
Global Emotional Intensity	.77** [.68, .84]	.26* [.06, .43]	.38** [.19, .53]	-.45** [-.59, -.28]	-		
Global Valence	-.42** [-.57, -.25]	-.19 [-.37, .009]	-.30* [-.47, -.11]	-			
Global Unwantedness	.37* [.18, .52]	.27* [.07, .44]	-				
Global Vividness	.19 [-.003, .38]	-					

Note. * = $p < .01$; ** = $p < .001$; $N = 100$; DPSS-R: Disgust Propensity and Sensitivity Scale – Revised; Bonferroni adjusted for ‘problematic’ memory characteristics (distress, vividness, unwantedness, valence and emotional intensity; $p < .01$) and ‘involuntary’ memory characteristics (retrieval ease and intent; $p < .025$).

Supplementary Table S4.9

Study 2b Correlation Coefficients for Involuntary Memory Global Characteristic Ratings (24-hour delay) with 95% Confidence Intervals.

	Global Distress	Global Vividness	Global Unwantedness	Global Valence	Global Emotional Intensity	Global Retrieval Ease	Global Intent
Total Memory Frequency	.26 [.04, .46]	.08 [-.15, .30]	.12 [-.11, .34]	-.11 [-.33, .12]	.25 [.03, .45]	.26* [.04, .46]	-.16 [-.37, .07]
DPSS-R Disgust Propensity Subscale	.31** [.09, .50]	.04 [-.19, .26]	.31** [.09, .51]	-.37** [-.55, -.15]	.40*** [.19, .57]	-.001 [-.23, .23]	-.09 [-.31, .14]
DPSS-R Disgust Sensitivity Subscale	.43*** [.22, .60]	.14 [-.09, .36]	.25 [.03, .45]	-.44*** [-.60, -.23]	.47*** [.27, .63]	-.02 [-.24, .21]	-.09 [-.31, .14]
Global Intent	-.29 [-.48, -.06]	-.43*** [-.60, -.22]	-.67*** [-.78, -.53]	.33** [.12, .52]	-.35** [-.53, -.13]	-.58*** [-.71, -.40]	-
Global Retrieval Ease	.11 [-.12, .33]	.52*** [.33, .67]	.31** [.08, .50]	-.03 [-.25, .20]	.13 [-.10, .35]	-	
Global Emotional Intensity	.76*** [.64, .84]	.33** [.11, .52]	.55*** [.37, .69]	-.51*** [-.66, -.33]	-		
Global Valence	-.58*** [-.72, -.41]	-.19 [-.40, .04]	-.50*** [-.66, -.31]	-			
Global Unwantedness	.53*** [.35, .68]	.31** [.09, .51]	-				
Global Vividness	.38*** [.17, .56]	-					

Note. * = $p < .025$; ** = $p < .01$; *** = $p < .001$; $N = 75$; DPSS-R: Disgust Propensity and Sensitivity Scale – Revised; Bonferroni adjusted for ‘problematic’ memory characteristics (distress, vividness, unwantedness, valence and emotional intensity; $p < .01$) and ‘involuntary’ memory characteristics (retrieval ease and intent; $p < .025$).

Chapter 5: Investigating Whether Disgust Memory Enhancement Extends to More Accurate Memory

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Author Contributions: I developed the study design with the guidance of MKTT and EKM. I collected the data, performed the data analysis and interpretation, and drafted the manuscript. MKTT and EKM made critical revisions to the manuscript. All authors approved the final version of the manuscript for submission.

Abstract

People show enhanced memory recall for disgust over fear, despite both being highly negative and arousing emotions. But does disgust's 'stickiness' in memory result in more false memories for disgust vs. fear? Existing research finds low false memory rates for disgust *and* fear, perhaps from using image lures depicting content *unrelated* to target images. Therefore, we presented 111 participants with disgust, fear, (and neutral) images amidst attention-monitoring task. After 24-48 hours, participants completed a recognition test where they viewed 'old' (previously seen) and 'new' images (both *related* and *unrelated* lures) and indicated whether each image was 'old' or 'new'. Relative to fear, participants experienced fewer false memories of disgust for *unrelated* lures, but similar false memories for *related* lures. Furthermore, participants' attention, correct recognition, and memory sensitivity were enhanced for disgust relative to fear. Our findings suggest disgust memory enhancement extends to *accurate* memory, which has methodological and clinical implications.

Introduction

Disgust occurs in various situations, from contamination threats (e.g., mould) to moral violations (e.g., murder). Like fear, disgust is negative, arousing, occurs during and following trauma, and predicts posttraumatic stress (PTS) symptoms (Matson et al., 2023). We know people attend to, and remember, disgust stimuli more than fear (Moeck et al., 2021). But does remembering disgust *more* mean remembering disgust *better* than fear? To answer this question, we need to establish that people are less likely to *falsely* remember disgust (than fear) stimuli. Existing research (e.g., Chapman et al., 2013) finds consistently low—and similar—false memory rates for disgust and fear, likely because 'new' image lures were unrelated to encoded 'old' images, among other limitations. Therefore, we compare disgust and fear false memory rates when test images are *related* (and unrelated) to encoded images.

People remember emotional—highly arousing and negative (or positive)—stimuli more than neutral stimuli (*emotionally enhanced memory*; Cahill & McGaugh, 1995). However, not all emotional stimuli are remembered equally (Levine & Pizarro, 2004). People freely recall more disgust-eliciting than fear-eliciting stimuli (termed *disgust memory enhancement*), even when these stimuli are matched on memory-enhancing variables like arousal, valence, distinctiveness (eye-catching/unusualness) and/or interrelatedness (Chapman et al., 2013; Chapman, 2018; Moeck et al., 2021; Schienle et al., 2021). Notably, remembering *more* disgust than fear is not the same as remembering disgust *better*—or more accurately—than fear. For example, someone may recall seeing a bloody leg, but may not accurately identify which (of two) bloody legs they previously saw. Alternatively, someone may recall seeing disgust images depicting different content to what they originally saw. In both cases, remembering *more* does not translate to *better* memory for disgust. Therefore, we wondered whether disgust memory enhancement extends to *accurate memory.*

The prevailing explanation for disgust memory enhancement is that people better encode disgust stimuli because they pay more attention to disgust than fear (Carretié et al., 2011). Across eye-tracking (Fink-Lamotte et al., 2022) and behavioural (Chapman et al., 2013) measures, disgust captures and holds attention more than fear. However, while some studies find disgust's attentional salience fully (Chapman, 2018) or partially (Chapman et al., 2013) accounts for disgust memory enhancement, other studies find no evidence for this idea (Matson et al., 2024; Moeck et al., 2021). Given this mixed evidence, perhaps *retrieval* mechanisms contribute to disgust memory enhancement. Specifically, people may be susceptible to disgust-specific *memory amplification* (Oulton et al., 2016; Southwick et al., 1997), potentially retrieving more true but also more *imagined* (false) details of disgust than fear stimuli. If so, disgust memory enhancement should result in more *false memories*. Because both encoding (attention) and retrieval (memory amplification) mechanisms may contribute to disgust memory enhancement, we consider competing hypotheses for disgust vs. fear false memory rates.

Perhaps people have *fewer* false memories for disgust than fear. According to Carretié et al.'s (2011) cost-and-benefit hypothesis, people maintain attention on disgust stimuli for longer than fear to "explore" costs and benefits. Exploring fear stimuli is costly because they require imminent/urgent action. Exploring disgust stimuli (e.g., contaminated food) is less costly because they are not imminently dangerous. Further, disgust stimuli are typically ambiguous, meaning exploring such stimuli has benefits (e.g., revealing the food is consumable). Therefore, people should have better memory sensitivity for disgust (i.e., can better distinguish disgust images they have/have not encoded), resulting in *fewer* false memories for disgust than fear.

However, there are two reasons why people may have *more* false memories for disgust than fear. First, although people struggle to disengage their attention from disgust, they may superficially explore disgust stimuli (i.e., attend but avoid encoding specific information; termed *attentional rubbernecking*), resulting in a weak memory trace (Fink-Lamotte et al., 2022). Second, the extended exploration and/or ambiguous nature of disgust may lead people to generate additional, imagined details about these stimuli (memory amplification; e.g., seeing an image of a dirty toilet and remembering a different dirty toilet). This process could increase feelings of familiarity toward related stimuli presented at test, reducing memory sensitivity and making participants more likely to judge such stimuli as "old" (i.e., experience *source monitoring errors*; Lindsay & Johnson, 2000) compared to related fear stimuli.

Alternatively, these predictions might counteract, resulting in *similar* false memory rates for disgust and fear. Research supports this possibility: people correctly recognise (i.e., respond "old" to test images seen at encoding) disgust images more than fear images but falsely remember (i.e., respond "old" to test images *not* seen at encoding) a similar, low, proportion of disgust and fear images (Chapman et al., 2013; Croucher et al., 2011; Marchewka et al., 2016; Schienle et al., 2021). But there are limitations to these studies.

Two studies use unrelated test image "lures" from broad emotion *categories* to capture false memories (Chapman et al., 2013; Marchewka et al., 2016). For example, showing a slug at encoding then a dirty toilet at test. Such *unrelated* images likely make the recognition test easy (Bowman & Dennis, 2015); participants can confidently reject new/unseen images, resulting in low false memory rates (.05 – .18). Giving participants the opportunity to falsely remember related—but not previously seen—images at test (e.g., showing different slugs at encoding and test; Schienle et al., 2021) should increase false memory rates, allowing us to reliably determine whether disgust memory enhancement extends to *accurate* memory.

Two studies had related test lures: each "old" image was paired with a "lure" image depicting similar content (Croucher et al., 2011; Schienle et al., 2021). These studies also found similarly low disgust and fear false memory rates (.04 – .20). But neither study normed "old" and "lure" image pairs on similarity/relatedness—i.e., how closely the images resembled one another. Thus, whilst conceptually similar, it is unclear whether these old/lure image pairs *looked* similar enough to make the recognition test difficult. These studies have other limitations: a G*Power sensitivity analysis indicates Croucher et al.'s (2011) sample size (N = 32) was insufficient to detect small effect sizes (η_p^2 <.05) for a repeated measures ANOVA, while Schienle et al. (2021) did not match their disgust and fear image sets on memory-enhancing variables (arousal, valence, distinctiveness[16]). We address these limitations by matching old/lure image pairs on similarity, closely matching disgust and fear image sets on memory enhancing variables, and recruiting a sufficient sample.

The Current Study

We tested our competing hypotheses by examining false memory rates for disgust vs. fear images using related *and* unrelated lures (to examine whether related lures increase false memory rates). Participants encoded disgust, fear, and neutral images whilst completing a task measuring attention. After 24-48 hours, participants completed a recognition test including "old" (previously seen) and "new" (not previously seen, related and unrelated) images. Along with our competing hypotheses, we expected participants would attend to disgust more than fear and neutral images at encoding (Matson et al., 2024), and correctly recognise more disgust than fear and neutral images at test (Chapman et al., 2013; Schienle et al., 2021).

[16] Due to the nature of memory recognition tests, they are relatively immune to differences in interrelatedness (Chapman et al., 2013).

We also examined response bias (tendency to say 'old' or 'new'). Due to mixed evidence on response bias differences between disgust and fear (Boğa et al., 2021), we aimed to clarify whether participants have a more—or similarly—liberal response bias for disgust vs. fear with no directional hypothesis. We had three exploratory interests: confidence in old/new judgements for lures, remember/know judgements to lures identified as "old", and correlations between memory for disgust, trait disgust, and PTS symptoms. Examining whether people are prone to falsely remember disgust (and fear) is clinically important: people feel both emotions during/following trauma (Badour & Feldner, 2018) and memory amplification correlates with worsening PTS symptoms (Oulton et al., 2016).

Study 3

Method

We pre-registered this study (https://osf.io/vbs9w); data (https://osf.io/7v6ax) are publicly available. We report how we determined sample size and all data exclusions, manipulations, and measures in both studies (Simmons et al., 2012). The Flinders University Social and Behavioural Research Ethics Committee approved this research.

Participants

Brysbaert (2019) suggests psychological research findings start to have practical and/or theoretical relevance at a medium effect size (d = .40). Thus, we based our target n = 110 on Brysbaert's recommendation for a 2 x 2 within-subjects design (our main analysis of interest) and predicting an interaction, using d = .40 with 80% power. We took the following pre-registered steps to ensure quality data. To prevent bots/server farmers from completing the surveys, participants had to pass pre-screening questions: a reCAPTCHA, an arithmetic question (i.e., 18 + 7 =) presented as an image, and score at least 8/10 on an English Proficiency Test (Moeck et al., 2022) to start the surveys. We embedded two attention checks (e.g., "If you are reading this, please select response 7") and two open-ended questions (e.g., “Please describe the image that captured your attention the most”) within the surveys. We recruited 131 participants living in the US from Amazon Mechanical Turk (MTurk) via CloudResearch (Litman et al., 2017) but excluded 20: one participant completed the encoding task twice, nine participants did not follow instructions for the encoding task, nine participants did not complete the recognition test, and one participant completed the recognition test too late (>72 hours after the encoding task).

Our final sample comprised 111 participants ranging from 24 – 78 years (*M* = 44.6, *SD* = 12.4); most were men (64.9%, women = 33.3%, non-binary = 0.9%, prefer not to say = 0.9%). Most participants were White/Caucasian (75.7%); other participants were Black/African American (9.9%), Latino/Hispanic (4.5%), East Asian (4.5%), Mixed Race (1.8%; as noted in the “other” option box), South Asian (0.9%), South-East Asian (0.9%), Mixed/Asian (0.9%), and one participant preferred not to disclose their ethnicity.

Materials

Image Set Development. We conducted several pilot studies to match our disgust and fear image sets on various memory-enhancing variables and ensure they evoked their target emotion. We first obtained ratings of disgust, fear, arousal, pleasantness, unpleasantness, and distinctiveness for potential disgust, fear and neutral images taken from several sources: the Nencki Affective Picture System (NAPS; Marchewka et al., 2014), a study by Chapman (2018), a study by Grootswagers et al. (2020), the Disgust Related Images database (DIRTI; Haberkamp et al., 2017), the Socio-Moral Image Database (SMID; Crone et al., 2018), the EmoMadrid database (Carretié et al., 2019), the Open Affective Standardized Image Set (OASIS; Kurdi et al., 2016), and the Crime and Threat Image Set (CaTIS; Noon et al, 2019). In total, 611 MTurk participants (53.0% women, 45.0% men, 1.1% non-binary, 0.7% ‘prefer not to say’, and 0.2% ‘other’) ranging from 20 – 75 years (M_{age} = 41.5, SD_{age} = 12.0) rated between 21 and 53 images each (from a pool of 362 images), until we had at least 50 ratings on each dimension per image. We excluded 147 images that were rated too high on the alternate emotion (e.g., disgust images rated > 4 on fear) and/or too low on the target emotion (e.g., disgust images rated < 4 on disgust), leaving 215 images.

From these eligible images, we created 333 pairs consisting of either two disgust or two fear images that had related content (e.g., there were 14 potential pairings of sharks). These pairs represented 20 distinguishable disgust themes (e.g., garbage, surgery, vomit) and 19 distinguishable fear themes (e.g., motor vehicle accident, snake, gun pointed at the screen). Next, to ensure the images in each pair were visually related to one another (Heathcote et al., 2009), a total of 250 MTurk Participants (54.4% women, 44.4% men, 1.2% non-binary, and 0.4% 'prefer not to say') ranging from 21 – 76 years (M_{age} = 42.9, SD_{age} = 11.5) rated image pairs on similarity (1 = *not similar at all*, 5 = *very similar*). Across several phases of piloting[17], participants rated a selection of potential pairs (from the 333 eligible image pairs) presented vertically/top-to-bottom.

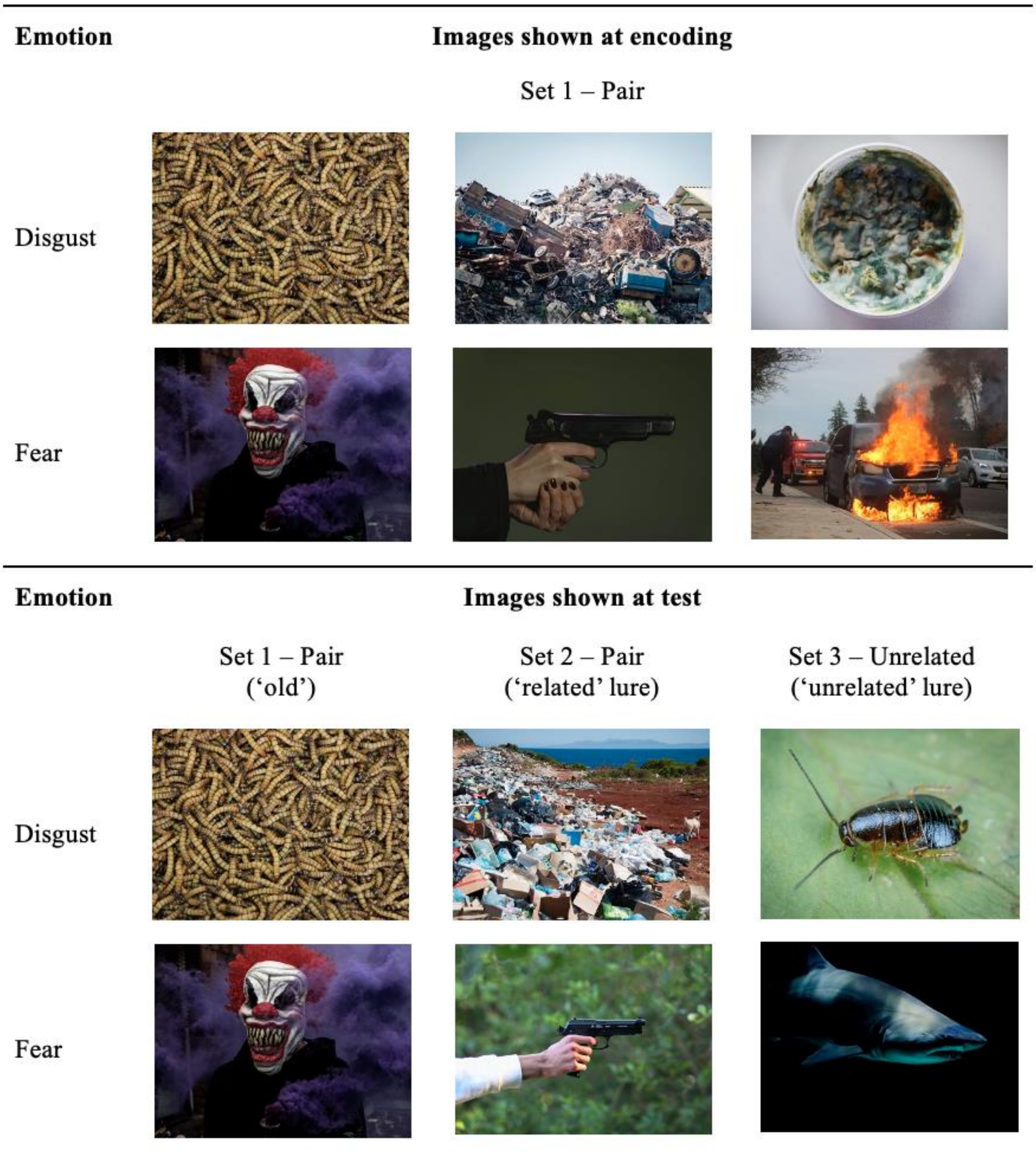
Images. Based on our pilot testing, we selected 36 disgust images (i.e., 12 pairs and 12 single unrelated images; rated high on disgust/low on fear) and 36 fear images (i.e., 12 pairs and 12 single unrelated images; rated high on fear/low on low on disgust). The unrelated images depicted different themes to the image pairs (e.g., seeing a dirty toilet at test, but not encoding). Of the disgust and fear image pairs, we only selected pairs rated high on similarity (>3) and ensured the image sets were comparable overall in similarity ratings (disgust image pairs: M = 4.1, SD = 0.9; fear image pairs: M = 4.1, SD = 0.8). Disgust images included injuries/deformity, death, mould, garbage, body products, dirty objects, and non-threatening animals. Fear images included threatening animals, weapons, scary faces, disasters-in-progress, and human attacks. See Appendix F for image codes and a full list of themes depicted in our image sets.

[17] At least 50 participants rated each image pair on similarity.

To eliminate order effects, we created sets of images and counterbalanced between participants so that some images were seen at encoding, and others at test. Specifically, we categorised disgust and fear images into three sets per emotion category: Set 1 – Pair (containing 12 images that had a corresponding pair), Set 2 – Pair (containing the 12 corresponding images to Set 1 – Pair) and Set 3 – Unrelated (containing 12 unrelated images). During encoding, participants viewed the disgust and fear images in either Set 1 – Pair *or* Set 2 – Pair. During test, participants viewed six disgust and six fear images from each of the three image sets. For example, among the three disgust sets participants viewed six "old" images (half of the images that they viewed at encoding), six "related lure" images (half of the images in the alternate pair image set), and six "unrelated lure" images (half of the images in Set 3 – Unrelated). Figure 5.1 shows an example of images shown to participants at encoding vs. test.

Figure 5.1

Examples of Disgust and Fear Image Themes Shown to Participants During the Encoding and Test Phases



Note. Here, images in 'Set 1 – Pair' were shown both at encoding and at test, test images in 'Set 2 – Pair' depict related pairs of images shown at encoding (from Set 1 – Pair), and test images in 'Set 3 – Unrelated' depicts content unrelated to what was shown at encoding. These public domain images are examples only and were not part of our image sets. Disgust and fear image themes depicted in our image sets are presented in Appendix F.

All six image sets (three disgust, three fear) were matched as closely as possible on arousal, pleasantness, unpleasantness and distinctiveness. Table 5.1 displays descriptive statistics for the disgust and fear image ratings overall[18]. To test whether the disgust and fear image sets were matched on arousal, pleasantness, unpleasantness, and distinctiveness, and differed on disgust and fear, we used the item analysis approach (like Chapman et al., 2013) where images are treated as 'subjects' (and each mean ratings score was averaged across all participants who rated that image). Participants rated the disgust and fear images as similarly distinctive, $t(70) = -1.52$, $p = .13$, $d = -0.36$. Fear images were significantly more arousing than disgust images ($t(70) = -3.32$, $p = .001$, $d = -0.78$), though this difference was small ($M_{\text{diff}} = 0.5$). Disgust images were significantly more unpleasant ($t(70) = 3.49$, $p < .001$, $d = 0.82$) and less pleasant ($t(70) = -3.40$, $p = .001$, $d = -0.80$) than fear images, though again these differences were small ($M_{\text{diff}} = 0.4$; $M_{\text{diff}} = 0.2$; respectively). Disgust and fear images differed on disgust ($t(70) = 15.69$, $p < .001$, $d = 3.70$) and fear ($t(70) = -12.58$, $p < .001$, $d = -2.97$) ratings, in the expected direction. The arousal and valence (i.e., pleasantness and unpleasantness) differences shown in our disgust and fear image sets are consistent with previous research (e.g., Chapman et al., 2013; Matson et al., 2024) and thus, likely reflect real-world differences between disgust and fear characteristics that are difficult to eliminate.

[18] Descriptive statistics for image ratings per the three disgust and three fear image sets appear in Supplementary Table S5.1.

Table 5.1

Ratings (M (SD)) for the Disgust and Fear Images

Rating Type (*scale*)	Disgust	Fear
Arousal (1 = *not at all arousing*, 7 = *highly arousing*)	3.5 (0.7)	4.0 (0.4)
Pleasantness (1 = *not at all pleasant*, 7 = *extremely pleasant*)	1.3 (0.2)	1.5 (0.3)
Unpleasantness (1 = *not at all unpleasant*, 7 = *extremely unpleasant*)	5.4 (0.6)	5.0 (0.4)
Distinctiveness (1 = *not at all distinctive,* 7 = *extremely distinctive*)	4.5 (0.8)	4.7 (0.5)
Disgust (1 = *not at all disgusting,* 7 = *extremely disgusting)*	5.0 (0.6)	2.7 (0.6)
Fear (1 = *not at all frightening*, 7 = *extremely frightening*)	2.9 (0.8)	4.6 (0.3)

Note. Descriptive statistics presented in Table 5.1 reflect all disgust images and all fear images collapsed into one set per emotion category. Descriptive statistics for disgust and images grouped per set (i.e., two image pair sets and one unrelated image set, per emotion category) are presented in Supplementary Table S5.1.

Regarding the neutral images, we selected 24 images displaying conceptually different (i.e., unrelated) content, rated low on all dimensions, except intermediate on pleasantness, $M = 4.5$, $SD = 0.8$. Neutral images[19] included common objects and everyday scenes.

Encoding Task: Line Discrimination. We used a line discrimination task (LDT) to measure attention toward each image during encoding. As in previous studies (e.g., Moeck et al., 2021), all 36 images appeared in a random order, for 2s each, accompanied by a horizontal white line 0.5cm above or below the image. We instructed participants to indicate the line's position as quickly as possible via keypress, with slower responses indicating

[19] Descriptive and inferential statistics for the neutral images are reported in Supplementary Table S5.2.

greater attention captured by each image. The image remained visible for the remaining time after the participant's response (e.g., 1500ms for a 500ms response).

Trait Disgust. We measured trait disgust—disgust sensitivity, disgust propensity, and disgust avoidance behaviours-—via two scales.

The Disgust Propensity and Sensitivity Scale – Revised (DPSS-R; Fergus & Valentiner, 2009) measures disgust propensity (six items; e.g., *'I avoid disgusting things'*) and disgust sensitivity (six items; e.g., *'When I feel disgusted, I worry that I might pass out'*; *1 = never, 5 = always*). The DPSS-R had good internal consistency (current study: propensity α = .83, sensitivity α = .85).

The 17-item Disgust Avoidance Questionnaire (DAQ; von Spreckelsen et al., 2022) measures people's tendency to avoid experiencing disgust and comprises three subscales: disgust prevention (e.g., '*I try hard to avoid situations that might bring up feelings of repulsion in me*'), cognitive disgust avoidance (e.g., '*I try hard to avoid thinking about a repulsive past situation*'), and behavioural disgust avoidance (e.g., '*I am quick to leave any situation that makes me feel disgusted*'; *1 = strongly disagree, 7 = strongly agree*). The DAQ had high internal consistency (current study: α = .97).

Posttraumatic Stress Disorder Checklist (PCL-5; Weathers et al 2013). Participants answered the PCL-5 in relation to their most traumatic/stressful life event. The PCL-5 comprises 20-items, including four subscales measuring key symptom clusters (re-experiencing, avoidance, negative alterations in cognition and mood, alterations in arousal and reactivity). Items (e.g., *'Repeated, disturbing, and unwanted memories of the stressful experience'*) are rated from 0 = *not at all* to 4 = *extremely*. The PCL-5 had high internal consistency (current study: α = .96).

Procedure

Encoding Phase. After passing pre-screening (reCAPTCHA, arithmetic question, English Proficiency Test), participants provided demographic information (gender, age, ethnicity). They then completed the LDT, where they encoded 12 disgust, 12 fear (Set 1 – Pair *or* Set 2 – Pair; set allocation was randomised across participants), and 12 neutral images, whilst indicating the location of a line (presented either above or below each image). Next, participants reported how closely they attended to the images (1 = *not at all closely*, 7 = *extremely closely*), if they closed their eyes or looked away from the images (*yes*/*no*) and if *yes*, for approximately how many images[20].

Test Phase. Following a 24-to-48-hour delay[21] (M = 30.2 hours, SD = 8.6 hours), participants completed a recognition test, where they viewed previously encoded ("old"), and never seen ("new"; lures) disgust, fear, and neutral images; the new disgust and fear images comprised both related (i.e., the image from the image pair that was not viewed during encoding) and unrelated images. Overall, at test, participants viewed 48 images in a randomised order comprising: six old images per emotion category, six related image lures (only for disgust and fear), and six unrelated image lures per emotion category. Participants indicated whether each image was "old" (i.e., previously seen) or "new" (i.e., not previously seen). Immediately after each old/new decision, participants rated their confidence in their answer (*1 = not at all, 5 = very*). If participants indicated an image was "old", they made a remember/know judgement. Participants were told that "remember" means they recognised the image as one they had seen during the encoding phase and "know" means the image seemed familiar but they did not explicitly recall viewing the image during the encoding

[20] Participants who did not closely attend to the images (i.e., reported ≤ 4 on the scale; n = 2) and/or who closed their eyes/looked away from > 4 images (n = 4) were already excluded from the study (due to not following instructions for the LDT or not completing Part 2).

[21] Five participants did not complete the recognition test within this time frame, and instead responded within 72 hours (following an additional reminder email at 48 hours post-encoding, as pre-registered); the average response time of these five participants was 54.3 hours post-encoding.

phase (full instructions for the recognition test are reported in Appendix J). After the recognition test, participants completed the PCL-5, and then the two disgust scales (DPSS-R and DAQ, in a randomised order), and were debriefed. Participants received $3.00USD; the study took approximately 30-min across both sessions to complete (Time 1: ~10-min; Time 2: ~20-min).

Results

Descriptive Statistics

Table 5.2 displays descriptive statistics for variables used in the main analyses.

Table 5.2

Descriptive Statistics for Main Variables by Image Emotion Category (Disgust, Fear, Neutral)

Variables	Disgust *N*	Disgust *M* (*SD*)	Fear *N*	Fear *M* (*SD*)	Neutral *N*	Neutral *M* (*SD*)
Related lures						
False memory rates (proportion)	111	.32 (.26)	111	.30 (.26)	-	-
Memory sensitivity (*d*')	109	1.3 (0.9)	107	1.1 (0.8)	-	-
Response bias (*c*)	109	-0.2 (0.9)	107	0.2 (1.1)	-	-
Confidence ratings (percentage)	111	72.8 (16.3)	111	69.0 (18.4)	-	-
Remember (proportion)	87	.47 (.41)	83	.42 (.43)	-	-
Know (proportion)	87	.53 (.41)	83	.58 (.43)	-	-
Unrelated lures						
False memory rates (proportion)	111	.13 (.21)	111	.22 (.23)	111	.10 (.20)
Memory sensitivity (*d*')	110	1.8 (0.7)	109	1.3 (0.9)	-	-
Response bias (*c*)	110	0.4 (0.8)	109	0.4 (1.0)	-	-
Confidence ratings (percentage)	111	75.8 (19.6)	111	71.1 (19.0)	-	-
Remember (proportion)	46	.41 (.46)	68	.38 (.43)	-	-
Know (proportion)	46	.59 (.46)	68	.62 (.43)	-	-
Correction recognition rates (proportion)	111	.76 (.21)	111	.65 (.26)	111	.36 (.27)
LDT response times (milliseconds)	111	646.9 (170.3)	111	629.6 (150.6)	111	609.3 (137.3)

Note. N values vary due to missing data for *d*' and *c* and because participants only provided remember/know ratings images they identified as 'old' (i.e., only 87 participants misjudged at least one related disgust lure as 'old' and thus, the remaining 24 participants correctly rejected all related disgust lures as 'new'.

Preliminary Analyses

Prior to examining our main research question relating to false memories, we first examined differences in attention and correct recognition between disgust, fear *and neutral* images (see Table 5.2 for descriptive statistics)[22]. First, we tested whether participants paid more attention (i.e., responded slower, in milliseconds) towards the disgust than fear—and the fear than neutral—images. Replicating previous studies (Chapman et al., 2013; Chapman, 2018; van Hooff et al., 2013; Matson et al., 2024; Moeck et al., 2021), participants paid greater attention when the line co-occurred with disgust compared to fear (M_{diff} = 17.4; 95% CI [4.4, 30.3], p = .009, η_p^2 = .06) and neutral (M_{diff} = 37.7; [24.1, 51.2], p < .001, η_p^2 = .22) images. Further, participants showed slower LDT responses when the line co-occurred with fear compared to neutral images, M_{diff} = 20.3; [9.6, 31.1], p < .001, η_p^2 = .11. Put differently, a one-way repeated measures ANOVA on LDT response times[23] revealed a significant effect of emotion category, F(2, 220) = 17.97, p < .001, η_p^2 = .14. Thus, the disgust images captured participants' attention longer than the fear and neutral images.

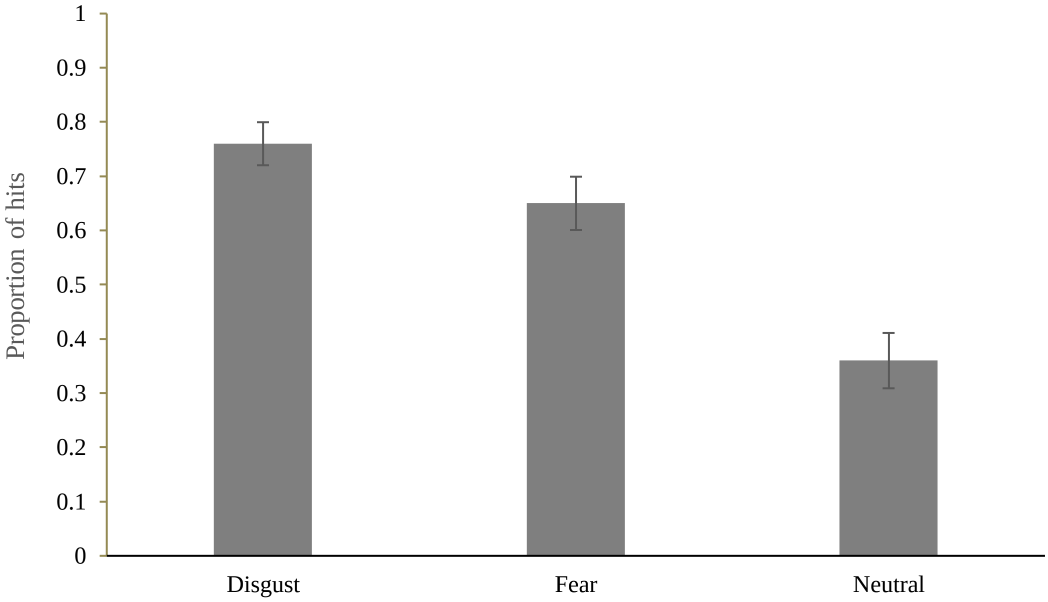
Next, we tested whether participants correctly recognised (i.e., hits) a higher proportion of disgust than fear—and fear than neutral—previously seen ('old') images. As shown in Figure 5.2, simple contrasts revealed participants correctly recognised more disgust than fear (M_{diff} = .10; 95% CI [.05, 1.0], p < .001, η_p^2 = .11) and neutral (M_{diff} = .39; [.34, .45], p < .001, η_p^2 = .11) images. Further, participants correctly recognised more fear than neutral (M_{diff} = .29; [.24, .34], p < .001, η_p^2 = .11) images. Put differently, a one-way repeated measures ANOVA revealed a significant effect of emotion category on correction recognition rates, F(2, 220) = 109.76, p < .001, η_p = .50. Thus, consistent with previous research (e.g., Schienle et al., 2021), participants correctly recognised more disgust than fear—and more

[22] Inferential statistics for the interaction between emotion (disgust, fear, neutral) on false memories for *unrelated* lures are reported in Supplementary Table S5.3.
[23] As pre-registered, we removed extreme outliers (> 3*SD* per participant) from the analysis.

fear than neutral—images, which suggests disgust memory enhancement extends to more *accurate* memory.

Figure 5.2

Mean Proportion of Correctly Recognised Disgust, Fear and Neutral Images (i.e., Hits) With 95% Confidence Intervals (Masson & Loftus, 2003)

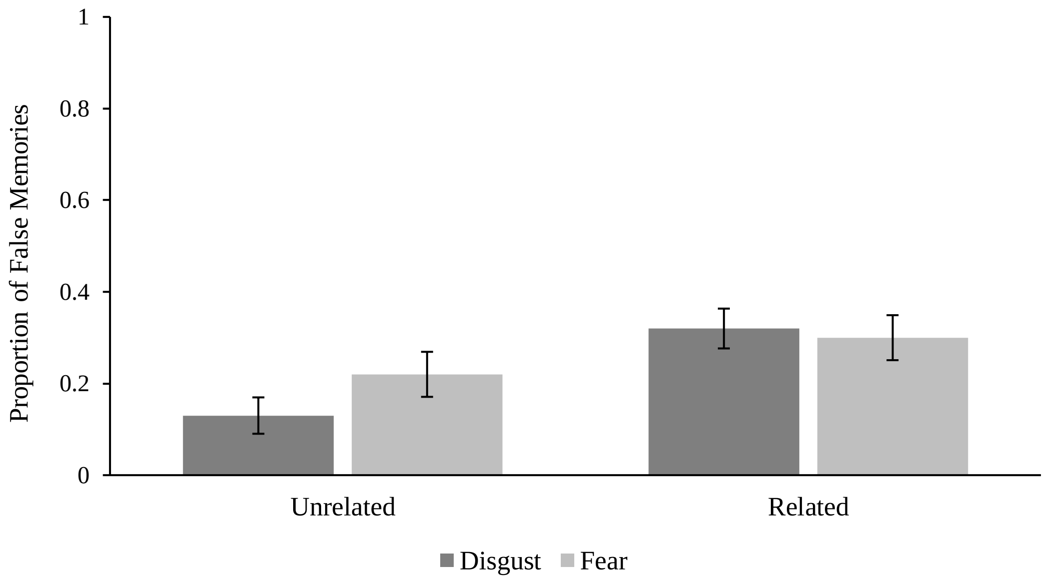


Main Analyses

Recall our primary aim was to determine whether participants had more, fewer, or a similar number of false memories for disgust, relative to fear images. Hereon, we omit neutral images from analyses and test the effects of emotion category (disgust, fear) and image lure type (related, unrelated) on memory recognition. As Figure 5.3 shows, a two-way repeated measures ANOVA revealed a statistically significant interaction between emotion (i.e., disgust, fear) and image lure type (i.e., related, unrelated) on false memory rates, $F(1, 110) = 11.40$, $p = .001$, $\eta_p^2 = .094$. Simple contrasts revealed a statistically significant difference between disgust and fear false memories for unrelated lures ($M_{diff} = .09$; 95% CI [.05, .12], $p < .001$, $\eta_p^2 = .16$) but not for related lures ($M_{diff} = .02$; [-.03, .07], $p = .40$, $\eta_p^2 = .006$). Consistent with the cost-and-benefit hypothesis (Carretié et al., 2011), participants had *fewer* false memories of disgust compared to fear images overall; a significant main effect of emotion category, $F(1, 110) = 5.38$, $p = .02$, $\eta_p^2 = .05$. Furthermore, participants had more false memories of related compared to unrelated lures; a significant main effect of lure type, $F(1, 110) = 77.61$, $p < .001$, $\eta_p^2 = .41$. Thus, these findings suggest people are less susceptible to falsely remembering disgust compared to fear stimuli but when there is a high likelihood of experiencing source monitoring errors (i.e., when stimuli are closely related), people are similarly susceptible to falsely remembering disgust and fear stimuli. We further test this idea by examining memory sensitivity for disgust relative to fear images (and for both lure types).

Figure 5.3

Mean Proportion of Disgust and Fear False Memories by Lure Type (Related, Unrelated) With 95% Confidence Intervals (Masson & Loftus, 2003)



We used a signal detection approach (i.e., correctly classifying an old image as "old" is a hit, incorrectly classifying a new image as "old" is a false alarm; Stainslaw & Todorov, 1999) to calculate memory sensitivity (*d*') and response bias (*c*). Descriptive statistics of *d*' and *c* for images in each emotion/lure type category appear in Table 5.2.

We first turn to memory sensitivity. A *d*' value of 0 indicates an inability to accurately distinguish between previously seen and unseen images, and larger values indicate an increased ability to accurately distinguish between previously seen and unseen images and thus, more genuine recognition. A two-way repeated measures ANOVA revealed a statistically significant interaction between emotion (disgust, fear) and image lure type (related, unrelated) on memory sensitivity, $F(1, 103) = 15.70$, $p < .001$, $\eta_p^2 = .13$. Simple contrasts showed a statistically significant difference between memory sensitivity for disgust and fear images, when comparing previously seen (old) images with new related lure images ($M_{diff} = 0.2$; 95% CI [0.04, 0.4], $p = .02$; $\eta_p^2 = .05$) and new unrelated lure images, $M_{diff} = 0.6$; [0.4, 0.8], $p < .001$; $\eta_p^2 = .27$). Also consistent with the cost-and-benefit hypothesis (Carretié et al., 2011), participants had *better* memory sensitivity for disgust compared to fear images; a significant main effect of emotion category, $F(1, 103) = 22.56$, $p < .001$, $\eta_p^2 = .18$. Furthermore, participants had *poorer* memory sensitivity for related compared to unrelated lures; a significant main effect of lure type, $F(1, 103) = 69.12$, $p < .001$, $\eta_p^2 = .40$. Our findings thus suggest participants' memory of disgust (relative to fear) images, and unrelated (relative to related) lures, was more accurate (i.e., they were better able to distinguish between image they had vs. had not seen before).

Next, we turn to response bias for disgust relative to fear images (both lure types), where $c < 0$ indicates a bias toward identifying test items as old (i.e., liberal response bias) and $c > 0$ indicates a bias toward identifying test items as new (i.e., conservative response bias). A two-way repeated measures ANOVA revealed a statistically significant interaction between emotion (disgust, fear) and lure type (related, unrelated) on response bias, $F(1, 103) = 15.70$, $p < .001$, $\eta_p^2 = .13$. Simple contrasts showed a statistically significant difference between response bias for disgust and fear images, when comparing previously seen (old) images with new related lure images ($M_{diff} = 0.4$; 95% CI [0.2, 0.6], $p < .001$; $\eta_p^2 = .12$), but not when comparing old images with new unrelated lure images, $M_{\text{diff}} = 0.04$; [-0.1, 0.2], $p = .68$; $\eta_p^2 = .002$). Participants had a more liberal response bias for disgust compared to fear images; a significant main effect of emotion category, $F(1, 103) = 5.98$, $p = .02$, $\eta_p^2 = .06$. Furthermore, participants had a more conservative response bias for unrelated compared to related lures; a significant main effect of lure type, $F(1, 103) = 69.12$, $p < .001$, $\eta_p^2 = .01$. Therefore, people make more liberal judgements for disgust relative to fear stimuli when there is a high likelihood of experiencing source monitoring errors (i.e., when stimuli are closely related). When source monitoring errors are less likely to occur (i.e., when stimuli are unrelated), people make similarly conservative judgements for disgust and fear stimuli.

Exploratory Analyses

We had three exploratory interests. First, we wondered whether participants' confidence in their old/new judgements differed for disgust and fear (as well as related and unrelated) image lures. A two-way repeated measures ANOVA revealed a non-significant interaction between emotion (disgust, fear) and image lure type (related, unrelated) on confidence ratings, $F(1, 110) = 0.33$, $p = .57$, $\eta_p^2 = .003$. However, participants were more confident in their judgements for disgust than fear images (a significant main effect of emotion, $F(1, 110) = 24.96$, $p < .001$, $\eta_p^2 = .19$) and in their judgements for unrelated than related image lures (a significant main effect of lure type, $F(1, 110) = 8.91$, $p = .003$, $\eta_p^2 = .08$). These results suggest participants were relatively aware of their memory ability; their confidence in their judgements translated to actual performance (i.e., participants had better memory sensitivity for disgust relative to fear images, and for unrelated relative to related image lures). When recognition was more difficult—as in, the likelihood of experiencing source monitoring errors increased—people were less confident in their responses.

Second, we wondered if participants made different "remember" (i.e., vividly remember viewing the image) vs. "know" (i.e., the image is familiar, though they don't explicitly remember viewing the image) judgments to the disgust and fear image lures they identified as 'old' (i.e., false memories). Higher "remember" judgements for false memories of a specific emotion category and/or lure type would indicate a weaker memory trace and increase in source monitoring errors for that emotion category/lure type (Holmes et al., 1998). A two-way repeated measures ANOVA revealed a non-significant interaction between emotion (disgust, fear) and image lure type (related, unrelated) on remember responses, $F(1, 37) = 0.01$, $p = .92$, $\eta_p^2 = .0003$. There were also no significant main effects ($F(1, 37) = 0.17$, $p = .68$, $\eta_p^2 = .01$ for emotion; $F(1, 37) = 0.54$, $p = .47$, $\eta_p^2 = .01$ for lure type). Because only a subset of participants ($n = 38$) experienced false memories of both related and unrelated lures—and thus only this subset gave remember/know ratings for images identified as 'old' in the above analyses—these results are underpowered and should be interpreted with caution. Nevertheless, these findings suggest participants similarly subjectively remembered the disgust and fear lure images.

Finally, we wondered whether memory for disgust (i.e., correct recognition, false memories, memory sensitivity and response bias) correlated with trait disgust and PTS symptoms. These data and descriptive statistics for trait disgust and PTS symptoms are reported in Supplementary Tables S5.4 and S5.5. Overall, memory for disgust did not significantly correlate with trait disgust (i.e., scores on the DPSS-R or DAQ) or PTS symptoms (i.e., scores on the PCL-5). These findings should be interpreted with caution since our sample size is likely too small to detect stable correlations (Schönbrodt & Perugini, 2013; 2018).

Discussion

We aimed to determine whether people experience fewer, similar, or more false memories for disgust vs. fear. We addressed past research limitations (e.g., Chapman et al., 2013) by using related *and* unrelated image lures and well-matched image sets. When image lures depicted content *unrelated* to ‘old’ images, participants falsely remembered fewer disgust than fear images. However, when image lures depicted content *related* to ‘old’ images, participants falsely remembered disgust and fear at a similar rate, but had a more liberal response bias for disgust than fear. Regardless of lure type, participants correctly recognised more, and had better memory sensitivity for, disgust than fear images. Together, these findings suggest disgust memory enhancement results in fewer false memories for disgust. Put otherwise, disgust memory enhancement extends to remembering disgust *more accurately* than fear.

In line with the cost-and-benefit hypothesis (Carretié et al., 2011), participants paid more attention to disgust than fear (as in Matson et al., 2024), and falsely remembered fewer disgust than fear images. Perhaps because of disgust’s ambiguous nature, participants explored—and encoded—disgust images longer than fear images, resulting in better memory for disgust. Consistently, participants had better memory sensitivity for disgust than fear images, even among related lures (where participants falsely remembered similar rates of disgust and fear related lures). Here, accurate memory for disgust was driven by participants’ ability to correctly recognise more ‘old’ disgust than fear images (rather than falsely remember fewer disgust than fear images). These findings disconfirm the proposition that people only superficially explore disgust stimuli leading to a weak memory trace (Fink-Lamotte et al., 2022).

Our finding that participants falsely remembered fewer—and for related lures, similar—disgust than fear images did not support our hypothesis regarding memory amplification (Southwick et al., 1997) or more source monitoring errors (Lindsay & Johnson, 2000) for disgust. Given memory amplification occurs when people remember more trauma-related details *over time* (Oulton et al., 2016), future research should examine whether disgust’s liberal response bias becomes more liberal over time, perhaps leading participants to say yes to more (old and new) images than they originally saw. Indeed, participants had a liberal response bias for disgust (i.e., typically responded ‘old’ to disgust images) and a conservative response bias for fear (i.e., typically responded ‘new’ to fear images). These results suggest participants used a more lenient criterion when judging disgust—relative to fear—images. Put differently, if participants were unsure of whether they had previously seen an image, they favoured identifying disgust images as ‘old’ and fear images as ‘new’. Notably, participants only showed a liberal response when we calculated response bias using old disgust images and *related* lures; perhaps they used a less lenient criterion because they felt surer about whether they previously saw the unrelated image lures.

There is a theoretical rationale for participants’ liberal response bias for disgust (and conservative bias for fear). Remembering disgust is important because disgust stimuli are subtle, easily/quickly spread, and resistant to decay (Chapman et al., 2013). This ease-of-transmission occurs for contamination-related disgust (e.g., infectious diseases) and for moral disgust (e.g., viewing a person who associates with immoral people—like paedophiles—as disgusting; Giner-Sorolla et al., 2018). Consistent with this idea, participants were more inclined to judge a ‘new’ disgust image as ‘old’ (‘false alarm’) than judge an ‘old’ disgust image as ‘new’ (‘miss’). Given the (real or perceived) ‘permanency’ of disgust, people may judge disgust more liberally because the consequences of missing a disgust threat (e.g., contracting an illness, social rejection) outweighs the consequences of falsely remembering disgust. Participants’ conservative response bias for fear suggests they ‘missed’ fear images. Given the ‘fleeting’ (non-permanent) nature of fear-inducing situations, people pay *less* attention to fear stimuli (Carretié et al., 2011). Thus, they may feel less confident in their memory, rejecting more (‘old’ and ‘new’) fear targets.

Our findings have methodological and clinical implications. Methodologically, given our study yielded higher false memory rates—for *related* lures only—than prior studies (e.g., Chapman et al., 2013), future research should use old/related lure pairs normed on similarity. Clinically, our results suggest false memories are not exacerbated for disgust experiences and thus, are not a disgust-specific factor that may worsen PTS symptoms. However, disgust's strong memory trace overall—and the risks associated with forgetting disgust (given disgust's 'permanency')—may explain why disgust memories are difficult to manipulate/reduce in PTSD treatments (Harned et al., 2015).

A limitation of our study is that—despite extensive piloting—the disgust and fear image sets were not equivalent on memory enhancing variables. Disgust images were more negative (less pleasant, more unpleasant) than fear images, and fear images more arousing than disgust images. Furthermore, our disgust images elicited disgust (M = 5.0) to a greater extent than our fear images elicited fear (M = 4.6). However, these differences were small, seen in other studies (Chapman et al., 2013; Matson et al., 2024), and likely reflect real world differences between disgust and fear (Faith & Thayer, 2001).

Disgust and fear are negative and arousing emotions with distinct cognitive effects. Whilst participants falsely remembered fewer disgust images, this effect was driven by unrelated lures; we saw no differences in false memories of disgust and fear *related* lures. Thus, people are similarly susceptible to source monitoring errors for disgust and fear stimuli when trying to distinguish between stimuli with similar content. Nevertheless, the present study found disgust memory enhancement extends to *accurate* memory, evidenced by fewer false memories overall, higher correct recognition rates, and better memory sensitivity for disgust than fear images.

Supplementary Materials

Supplementary Table S5.1

Ratings (M (SD)) for each disgust and fear image set.

	Disgust			Fear		
Rating Type	Set 1 Pair	Set 2 Pair	Set 3 Unrelated	Set 1 Pair	Set 2 Pair	Set 3 Unrelated
Arousal	3.6 (1.8)	3.6 (1.7)	3.6 (1.8)	4.0 (1.8)	4.0 (1.9)	4.0 (1.8)
Pleasantness	1.3 (0.7)	1.3 (0.7)	1.4 (0.8)	1.4 (0.9)	1.5 (0.9)	1.6 (1.0)
Unpleasantness	5.4 (1.4)	5.4 (1.4)	5.4 (1.5)	5.0 (1.6)	5.0 (1.7)	5.0 (1.5)
Distinctiveness	4.4 (1.6)	4.4 (1.5)	4.8 (1.6)	4.8 (1.5)	4.8 (1.5)	4.5 (1.6)
Disgust	5.0 (1.6)	5.0 (1.6)	5.0 (1.6)	2.7 (1.7)	2.8 (1.9)	2.6 (1.7)
Fear	2.9 (1.8)	2.8 (1.8)	2.9 (1.9)	4.6 (1.8)	4.6 (1.8)	4.6 (1.8)

Supplementary Table S5.2

Descriptive (Ms and (SDs)) and inferential statistics (independent samples t-tests) for neutral images.

Outcome Variable	*M* (*SD*)	*Emotion comparison for t-test*	*df*	*t*	*p*	95% CI	Cohen's *d*
Arousal	2.0 (0.5)	Neutral vs. Disgust	58	8.82	< .001	1.16 – 1.84	2.32
Arousal		Neutral vs. Fear	39.75	16.84	< .001	1.72 – 2.19	4.70
Pleasantness	4.5 (0.8)	Neutral vs. Disgust	24.92	-19.46	< .001	-3.55 – -2.87	-6.15
Pleasantness		Neutral vs. Fear	27.36	-17.79	< .001	-3.36 – -2.66	-5.47
Unpleasantness	1.3 (0.2)	Neutral vs. Disgust	42.37	39.44	< .001	3.86 – 4.28	8.71
Unpleasantness		Neutral vs. Fear	48.59	47.79	< .001	3.50 – 3.81	10.82
Distinctiveness	2.8 (0.7)	Neutral vs. Disgust	57	8.68	< .001	1.32 – 2.11	2.32
Distinctiveness		Neutral vs. Fear	36.24	11.93	< .001	1.61 – 2.28	3.43
Disgust	1.1 (0.1)	Neutral vs. Disgust	38.07	38.26	< .001	3.65 – 4.06	8.30
Disgust		Neutral vs. Fear	37.73	14.99	< .001	1.38 – 1.82	3.25
Fear	1.2 (0.1)	Neutral vs. Disgust	37.92	13.18	< .001	1.45 – 1.97	2.86
Fear		Neutral vs. Fear	48.34	55.78	< .001	3.33 – 3.58	12.61

Note. $N = 24$ (except $N = 23$ for distinctiveness ratings)

Supplementary Table S5.3

Inferential statistics for the interaction between emotion (disgust, fear, neutral) on false memories for unrelated lures.

Analysis	Inferential Statistic
One-way repeated measures ANOVA (emotion: disgust, fear, neutral)	$F(2, 220) = 12.75$, $p < .001$, $\eta_p = .10$.
Simple contrast between disgust and fear	$M_{diff} = .09$; 95% CI [.05, .12], $p < .001$; $\eta_p^2 = .16$
Simple contrast between disgust and neutral	$M_{diff} = .02$; 95% CI [-.03, .07], $p = .37$; $\eta_p^2 = .007$
Simple contrast between fear and neutral	$M_{diff} = .1$; 95% CI [.06, .2], $p < .001$; $\eta_p^2 = .15$

Note. Contrary to our prediction, when image lures depicted content that was unrelated to the content in images presented during encoding, .participants experienced *more* false memories of fear compared to disgust and neutral images, and a *similar* proportion of false memories of disgust and neutral images

Supplementary Table S5.4

Descriptive statistics (M, SD, range) for posttraumatic stress and trait disgust measures.

Questionnaire	*M*	*SD*	*Range (minimum – maximum)*
PCL-5 total	15.1	17.5	0 – 65
PCL-5 re-experiencing subscale	3.6	4.7	0 – 17
PCL-5 avoidance subscale	2.4	2.6	0 – 8
PCL-5 negative alterations in cognition and mood subscale	5.0	6.7	0 – 24
PCL-5 alterations in arousal and reactivity subscale	4.2	5.2	0 – 20
DPPS-R disgust propensity subscale	16.5	4.2	6 – 28
DPPS-R disgust sensitivity subscale	12.1	5.0	6 – 26
DAQ total	85.2	21.4	17 – 119
DAQ behavioural subscale	45.6	11.3	9 – 63
DAQ cognitive subscale	39.6	11.2	8 – 56
DAQ prevention subscale	45.2	11.8	9 – 63

Note. $N = 111$. PCL-5: Posttraumatic Stress Disorder Checklist; DPSS-R: Disgust Propensity and Sensitivity Scale – Revised; DAQ: Disgust Avoidance Questionnaire. On average, participants reported subthreshold PTSD symptom levels based on the PCL-5 cut-off (31; Ashbaugh et al., 2016). According to this cut-off, 19.8% of the sample ($n = 22$) were PTSD-probable.

Supplementary Table S5.5

Correlations between correction recognition (i.e., hits), false memories (i.e., false alarms), memory sensitivity (i.e., d') and response bias (i.e., c) for disgust images, with trait disgust and PTS symptom measures.

	Hits	False alarms (related lures)	False alarms (unrelated lures)	*d*' (hits vs. related lures)	*d*' (hits vs. unrelated lures)	*c* (hits vs. related lures)	*c* (hits vs. unrelated lures)
DPSS-R disgust propensity subscale	.12 [-.07, .30]	-.03 [-.22, .16]	.07 [-.12, .25]	.11 [-.08, .30]	.05 [-.14, .24]	-.06 [-.24, .13]	-.13 [-.31, .06]
DPSS-R disgust sensitivity subscale	-.0004 [-.19, .19]	-.04 [-.23, .14]	.13 [-.06, .31]	.06 [-.13, .24]	-.08 [-.26, .11]	.02 [-.17, .20]	-.10 [-.29, .09]
DAQ behavioural subscale	.11 [-.08, .29]	-.09 [-.27, .10]	-.09 [-.27, .10]	.12 [-.07, .30]	.13 [-.06, .31]	.02 [-.17, .20]	.0005 [-.19, .19]
DAQ cognitive subscale	.06 [-.13, .25]	-.07 [-.25, .12]	-.20 [-.37, -.01]	.07 [-.12, .25]	.19 [.001, .36]	.008 [-.18, .20]	.11 [-.08, .29]
DAQ prevention subscale	.06 [-.13, .25]	-.07 [-.25, .12]	-.15 [-.33, .03]	.06 [-.13, .25]	.14 [-.05, .32]	.01 [-.17, .20]	.08 [-.11, .27]
DAQ total	.09 [-.10, .27]	-.08 [-.26, .11]	-.15 [-.33, .04]	.10 [-.09, .28]	.16 [-.02, .34]	.01 [-.18, .20]	.06 [-.13, .24]
PCL-5 re-experiencing subscale	.00007 [-.19, .19]	.19 [.004, .36]	.20 [.01, .37]	-.10 [-.28, .09]	-.08 [-.27, .11]	-.18 [-.36, .01]	-.17 [-.35, .02]
PCL-5 negative alterations in cognition and mood subscale	-.01 [-.20, .17]	-.04 [-.22, .15]	.09 [-.10, .27]	.06 [-.13, .24]	-.04 [-.23, .14]	.02 [-.17, .21]	-.07 [-.26, .12]
PCL-5 avoidance subscale	-.008 [-.19, .18]	.14 [-.05, .32]	.07 [-.12, .25]	-.07 [-.26, .12]	-.02 [-.21, .16]	-.09 [-.27, .10]	-.05 [-.24, .14]
PCL-5 alterations in arousal and reactivity subscale	-.06 [-.25, .13]	.005 [-.18, .19]	.09 [-.09, .28]	.002 [-.19, .19]	-.07 [-.25, .12]	.004 [-.18, .19]	-.05 [-.24, .14]
PCL-5 total	-.03 [-.21, .16]	.06 [-.13, .24]	.13 [-.06, .31]	.02 [-.20, .17]	-.06 [-.25, .13]	-.05 [-.24, .14]	-.10 [-.28, .09]

Note. N = 111 for hits and false alarm analyses; *n* = 109 for related lure *d*' and *c* analyses; *n* = 110 for unrelated lure *d*' and *c* analyses. Bonferroni adjusted for unrelated and related lures (*p* = .025 for all memory variables except for 'Hits'). DPSS-R: Disgust Propensity and Sensitivity Scale – Revised; DAQ: Disgust Avoidance Questionnaire; PCL-5: Posttraumatic Stress Disorder Checklist.

Chapter 6: Investigating Whether Feelings of Disgust Persist in Memory

Chapter 6 is submitted for publication:

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Author Contributions: I developed the study design with the guidance of MKTT and EKM. I collected the data, performed the data analysis and interpretation, and drafted the manuscript. Data from Study 4a are from the same sample as data from Study 1. MKTT and EKM made critical revisions to the manuscript. All authors approved the final version of the manuscript for submission.

Abstract

Persistent negative emotions are a key post-traumatic stress (PTS) symptom. *Disgust* is a negative emotion that occurs during/following traumatic events and predicts PTS symptoms. But disgust is overlooked relative to other negative emotions like fear. Here, we investigate how trauma-related disgust fades—or persists—in memory (i.e., when recalling peritraumatic vs. current [posttraumatic] feelings), relative to fear. In a cross-sectional (Study 4a; $N = 471$) and longitudinal (Study 4b; $N = 160$) study, participants rated their disgust and fear reactions to a recent stressful/traumatic event, at the time the event occurred (peritraumatic; ‘then’) and at present (posttraumatic; ‘now’). Study 4b participants provided additional ‘now’ emotion ratings three-months later. Cross-sectional comparisons showed that whilst participants’ disgust and fear reactions faded in intensity from ‘then’ to ‘now’, disgust persisted in memory more than fear (i.e., fear faded to a greater degree than disgust). In contrast, disgust and fear similarly persisted longitudinally. PTS symptom severity and time since the traumatic event did not explain these findings. We conclude disgust and fear similarly persist over time, but disgust persists in memory more than fear. Understanding

how to reduce feelings of disgust following trauma is clinically important, since disgust is more resistant to PTSD treatments than fear.

Introduction

Disgust can occur in response to physically revolting stimuli (e.g., injury, bodily fluids) and morally reprehensible acts (e.g., murder, sexual assault; Chapman & Anderson, 2012). It is unsurprising, then, that various traumatic events can evoke intense peritraumatic (i.e., at the time the event occurred) and posttraumatic (i.e., after the event occurred) disgust reactions (Badour & Feldner, 2018). Importantly, trauma-related disgust reactions are more difficult to reduce, relative to fear reactions, in common PTSD therapies (i.e., exposure therapy; Harned et al., 2015), perhaps because people remember feeling persistently intense disgust, but less intense fear after the traumatic event has subsided. However, even though it is only when negative emotional responses *persist* over time that a person can meet Criterion D4 for PTSD (APA, 2022), researchers have not measured how specific trauma-related emotional reactions differentially—or, similarly—persist in memory. Therefore, here, we explored whether people's memory for feeling *disgusted* is more 'sticky'—or more likely to persist or less likely to fade over time—than their memory for feeling fear.

Emotional responding to traumatic events has typically been understood in the context of fear, horror and helplessness (APA, 1994). However, research over the past two decades shows that people can experience a range of negative emotional reactions—beyond fear—in response to traumatic events (Badour et al., 2013c; Friedman et al., 2011; Hathaway et al., 2010). Consequently, PTSD diagnostic criteria now include persistent feelings of fear, horror, helplessness, anger, shame, and/or guilt as a symptom (APA, 2022). Notably, these criteria do not explicitly recognise persistent feelings of *disgust*. This oversight is significant because feelings of disgust occur in response to traumatic experiences in various populations (e.g., veterans, Bomyea & Allard, 2017; sexual abuse survivors, Coyle et al., 2014; natural disaster survivors; Fredman et al., 2010). Moreover, trauma-related disgust reactions uniquely predict posttraumatic stress (PTS) symptoms, like involuntary memories or “intrusions”, even after controlling for fear reactions (Badour et al., 2013c; Matson et al., 2023).

Existing research on trauma-related disgust has cross-sectionally measured—but not compared—peritraumatic (i.e., at the time the traumatic event occurred) and posttraumatic (i.e., after the traumatic event occurred) disgust reactions (Badour et al., 2012; Bomyea & Allard, 2017). In these studies, researchers typically ask participants to retrospectively rate trauma-specific (i.e., peritraumatic and/or posttraumatic) disgust reactions either using single-item disgust measures (e.g., on a 0 – 100 scale; Badour et al., 2012) or questionnaires. For example, Bomyea and Allard developed the 17-item Trauma-Related Emotions Questionnaire to measure peri- and posttraumatic disgust (e.g., *feeling repulsed*, from 0 [*very slightly or not at all*] to 6 [*extremely*]) and fear (e.g., *feeling terrified*) reactions in response to a traumatic event. These studies investigate whether disgust predicts PTS symptoms, finding posttraumatic disgust reactions mediate the relationship between peritraumatic disgust reactions and PTS symptoms. In other words, disgust reactions may only be detrimental to PTS symptoms when they *persist* after the traumatic event has occurred. However, this proposal has not been directly tested. That is, research has not examined whether the intensity of people’s disgust and fear reactions increases, decreases or persists peri- to post-trauma. It has also not compared posttraumatic disgust (and fear) reactions *longitudinally* (i.e., across more than one timepoint).

Emotional reactions associated with negative and traumatic events typically fade in intensity over time (Walker & Skowronski, 2009). Research evaluating emotional fading usually compares positive and negative *affect*, finding negative affect associated with specific autobiographical memories fades more quickly than the positive affect associated with these memories (termed the *fading affect bias*; Skowronski et al., 2014; Walker & Skowronski, 2009). Importantly, the fading affect bias can be disrupted (i.e., negative affect fades at a slower rate compared to usual) among people with dysphoria, depression, and PTSD (Bond et al., 2022; Marsh et al., 2019). Research has not explored whether some *discrete* emotions fade faster than others (which we term a *differential fading emotion bias*). Yet, theories of emotional conditioning (e.g., Olatunji et al., 2007b) and emerging memory research (e.g., Moeck et al., 2021) suggest trauma-related disgust and fear reactions may differentially fade over time.

Disgust and fear reactions are formed through classical conditioning (i.e., pairing an unconditioned stimulus [UCS] with a conditioned stimulus [CS], which produces the conditioned emotional response) and operant conditioning (i.e., avoiding stimuli that elicit the emotional response reinforces future avoidance) processes (Badour & Feldner, 2018). However, disgust reactions can also form via an added layer of conditioning, termed *evaluative conditioning* (Olatunji et al., 2007b). Here, an affective value (e.g., disgust) is placed onto the UCS, even if there is no expectation that the CS will occur again (De Houwer et al., 2001). In the context of trauma, evaluative conditioning may involve transferring disgusting aspects of the experience onto the self or others (Badour & Feldner, 2018). For example, a police officer investigating child exploitation may view themselves as disgusting for witnessing such content. Disgust is more difficult—compared to fear—to extinguish through targeted intervention (Harned et al., 2015; Olatunji et al., 2007b), suggesting emotions elicited via evaluative conditioning may be particularly memorable.

In line with this idea, growing evidence suggests disgust elicitors persist longer in memory than fear elicitors. For example, when asked to recall negative images they recently viewed, people remembered more disgust than fear images (Chapman et al., 2013; Moeck et al., 2021). Further, Moeck et al. found this pattern increased over time (and attention at encoding did not account for this effect). Comparatively, whilst people experience a similar number of intrusions for disgust and fear images, disgust-related intrusions become more emotionally intense relative to fear-related intrusions over a 24-hour delay (Matson et al., 2024). Regarding memory accuracy, people correctly recognise previously encoded disgust images better than fear images (Chapman et al., 2013; Schienle et al., 2021). Beyond analogue experimental designs and in the context of personal/lived trauma, disgust reactions uniquely predict ‘problematic’ intrusion characteristics implicated in the development and maintenance of PTSD (e.g., distress), as well as intrusion severity (i.e., persistence of intrusion symptoms over one month) more broadly (Matson et al., 2023). Taken together, these findings suggest disgust elicitors are memorable, to a greater—or at minimum, comparable—extent relative to fear elicitors. However, we are not aware of any research that directly compares how disgust (and fear) emotions themselves may differentially persist in memory over time (i.e., peritraumatic vs. posttraumatic emotional intensity). Investigating memory for emotions is important because—due to finite cognitive resources—it is both efficient and common to remember the emotions associated with an event long after the details of an experience are forgotten (Levine et al., 2009).

The current studies

Our research question is: *Do disgust reactions to a recent traumatic event persist in memory to a greater extent than fear reactions?* We compared the intensity of disgust and fear reactions to participants’ most stressful or traumatic event from the past six-months. In Study 4a—a cross-sectional design—we asked participants to rate how disgusted and frightened they felt at the time the event occurred (i.e., peritraumatic, termed ‘then’ from hereon) and when presently thinking about the event (i.e., posttraumatic, termed ‘now’ from hereon). In Study 4b—a longitudinal design—we asked participants to rate how disgusted and frightened they felt about the event at two time points: Time 1 (where they provided ‘then’ and ‘now’ ratings, to replicate our Study 4a main findings) and following a three-month delay (i.e., Time 2, where they only provided ‘now’ ratings). Our cross-sectional design measures people’s memory of how disgusted/frightened they felt during their traumatic event (‘then’) relative to how they currently feel (‘now’). Our longitudinal design measures emotions as they are experienced over time (i.e., ‘now’), rather than memory of past emotions. Consistent with the fading affect literature (Walker & Skowronski, 2009), we expected disgust and fear reactions to be stronger ‘then’ vs. ‘now’ at Time 1, as well as stronger for Time 1 ‘now’ vs. Time 2 ‘now’. However, we expected the difference between disgust reactions to be smaller than for fear (indicating disgust’s persistence in memory).

We had two secondary interests. First, we wondered whether PTS symptom severity related to emotional fading; specifically, whether higher PTS symptom scores (Study 4a) and stable PTS symptom severity scores over time (i.e., no change over three-months; Study 4b) related to greater emotional persistence. Second, we wondered whether more recent traumatic events (e.g., one vs. five months ago) related to less emotional fading over time. We pre-registered[24] both studies (Study 4a: https://osf.io/wbkp4; Study 4b: https://osf.io/a6h5u). Data (https://osf.io/utq4e), study materials (Study 4a: https://osf.io/bfc4p; Study 4b: https://osf.io/b2y9c) and supplementary material (https://osf.io/63xbp) are publicly available.

Study 4a

Method

We report how we determined sample size and all data exclusions, manipulations, and measures in both studies (Simmons et al., 2012). The Flinders University Social and Behavioural Research Ethics Committee approved this research.

We took the following pre-registered steps in both studies to ensure quality data. To prevent bots/server farmers from completing the surveys, participants had to pass pre-

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[24] Hypotheses pre-registered in Study 4a were part of a larger study (Matson et al., 2023) and we did not report specific hypotheses for the differential fading of disgust and fear. We pre-reregistered hypotheses for the differential fading of disgust and fear for Study 4b.

screening questions: a captcha, an arithmetic question (i.e., 3+4=) presented as an image, and score at least 8/10 on an English Proficiency Test (Moeck et al., 2022) to start the surveys. We embedded three attention checks (e.g., “If you are reading this, please select option 5”) and one open-ended question about the study’s purpose within the surveys.

Transparency and openness

The data reported in Study 4a were collected as part of a larger study examining the relationship between trauma-related disgust reactions and intrusion symptoms (see Study 1 and Matson et al., 2023); below we focus on details relevant to answering the current research question.

Participants

For the purposes of a larger study (Matson et al., 2023; https://osf.io/b249a/), we aimed to recruit a minimum of 260 participants (because correlations stabilise at this size; Schönbrodt & Perugini, 2013; 2018) with at least one trauma-related intrusion. We recruited 474 participants from Amazon Mechanical Turk (MTurk) via CloudResearch (Litman et al., 2017). We excluded three participants: two provided answers consistent with bots/farmers to the open-ended question (e.g., “nice”) and one failed all three attention checks (Agley et al., 2021).

Our final sample comprised 471 participants ranging from 19–88 years (M = 42.7, SD = 13.1); roughly half were women (52.7%, men = 45.9%, non-binary = 0.6%, prefer not to say = 0.9%). Most participants were American (including “African American”, “Native American”, “Chinese American” and “European American”, 94.5%). Others were Chinese (0.4%); Korean (0.4%); Bahamian (0.2%); Malaysian (0.2%); Indian (0.2%); Vietnamese (0.2%); Puerto Rican (0.2%); Russian (0.2%); German (0.2%). Some provided their ethnicity instead of nationality (e.g., “White” and/or “Caucasian”, 2.8%; “Asian”, 0.4%).

Materials

Trauma History Screen (THS; Carlson et al., 2011). The THS measures exposure to high magnitude stressor (HMS) events (i.e., sudden events that cause extreme distress in most people; e.g., *seeing someone die suddenly or get badly hurt or killed*), satisfying DSM-4 PTSD Criterion A1 (APA, 1994). We adapted the THS to measure exposure in the last six months to control for time since the event, and because memories are retrieved easier for recent events (Rubin & Berntsen, 2009). Therefore, we removed items referring to childhood events. Participants indicated whether they experienced any of the remaining 12-HMS events within the last six months. Participants then indicated whether the event/s "*really bothered [them] emotionally*" (*yes/no/I did not experience any of the events*). If *Yes*, participants (*n* = 322) briefly described the event that bothered them the most, classified as their most traumatic event from the last six months. If *No* or *I did not experience any of the events*, participants (*n* = 149) briefly described their most stressful event from the last six months, which we coded into additional event-type categories (see Supplementary Table S6.1). Then, all participants indicated how long ago (*months/days*) their most traumatic/stressful event occurred, how much they were bothered by the event (*1 = not at all, 5 = very much*), and for how long (*1 = not at all, 4 = a month or more*). The THS has excellent 1-week test-retest reliability (.93; Carlson et al., 2011).

Emotional reactions. Participants rated how intensely they felt/feel four specific emotions (fear, disgust, anger, compassion; *1 = not at all, 7 = extremely*) both when remembering these emotions from at the time their most traumatic/stressful event occurred (i.e., then), and when they presently think about the event (i.e., now). We measured these emotional reactions using single-items, previously extensively used to investigate peri- and post-traumatic emotional intensity (e.g., Badour et al., 2012; Hathaway et al., 2010). We included *compassion*—a posttraumatic growth-related emotion (Tedeschi & Calhoun, 2004)—and *anger*—a PTSD-relevant emotion (APA, 2022)—to deter participants from guessing the study's hypotheses.

Posttraumatic Stress Disorder Checklist (PCL-5; Weathers et al., 2013). Participants answered the PCL-5 in relation to the same traumatic/stressful life event that they described in the THS. The PCL-5 comprises 20 items assessing PTSD symptoms in the past month (i.e., *'Repeated, disturbing, and unwanted memories of the stressful experience'*; 1 = *not at all*, 5 = *extremely*). The PCL-5 had high internal consistency (current study: α = .95).

Procedure

After passing pre-screening (reCAPTCHA, English Proficiency Test etc.), participants provided demographic information (i.e., gender, age, nationality) before completing the THS. Next, they answered the emotional reactions questionnaire in relation to their most traumatic event in the last six months (indicated in the THS)—'then' (i.e., "at the time the event occurred") and 'now' (i.e., "at this moment") questions were presented in a counterbalanced order. Participants then completed the PCL-5 and additional measures not analyzed here (see https://osf.io/bfc4p for all study measures), before being debriefed and provided with support and services for any emotional discomfort experienced. Participants received $1.20USD; the survey took approximately 14-min to complete.

Results

Descriptive Statistics

Table 6.1 displays descriptive statistics for variables used in the main analyses. Event-related emotional reactions were low-moderate in intensity overall; disgust reactions were less intense than fear reactions. On average, participants reported subthreshold PTSD symptom levels, based on the PCL-5 cut-off (31; Ashbaugh et al., 2016). According to this cut-off, 28.9% of the sample (n = 136) were PTSD-probable.

Table 6.1

Descriptive statistics for main variables in Study 4a

Measures	*Scale*	*Range*	*M (SD)*
Event-related disgust (‘then’)	1—7	1—7	2.7 (2.2)
Event-related disgust (‘now’)	1—7	1—7	2.6 (2.1)
Event-related fear (‘then’)	1—7	1—7	4.5 (2.2)
Event-related fear (‘now’)	1—7	1—7	3.2 (2.1)
PCL-5 total	0—80	0—80	23.0 (17.4)

Note. PCL-5 = Posttraumatic Stress Disorder Checklist.

We descriptively examined whether event type and time since the event varied the overall low-moderate levels of disgust/fear reactions. First, we examined disgust and fear emotional reaction scores separated by stressful/traumatic event type (see Supplementary Table S6.2 for full details). People experienced similarly intense disgust and fear reactions (both ‘then’ and ‘now) for the following event types: ‘hit or kicked hard enough to injure’, ‘forced or made to have sexual contact’, ‘attack with a gun, knife or weapon’, ‘suddenly abandoned by spouse, partner, parent, or family’ and ‘relationship issues’. However, these five events only comprised 11.9% of total participants’ worst events. For most other event types, people generally experienced less intense disgust relative to fear reactions.

Next, we examined disgust and fear emotional reaction scores separated by time since the traumatic event occurred (see Supplementary Table S6.2). We converted each month reported by participants in the THS to 30 days (i.e., five months = 150 days) and summed these month totals with participants’ additional number of days to create a continuous variable of time[25], used in later analyses. Both number of participants and disgust/fear emotional intensity ratings were similarly dispersed across each monthly increment.

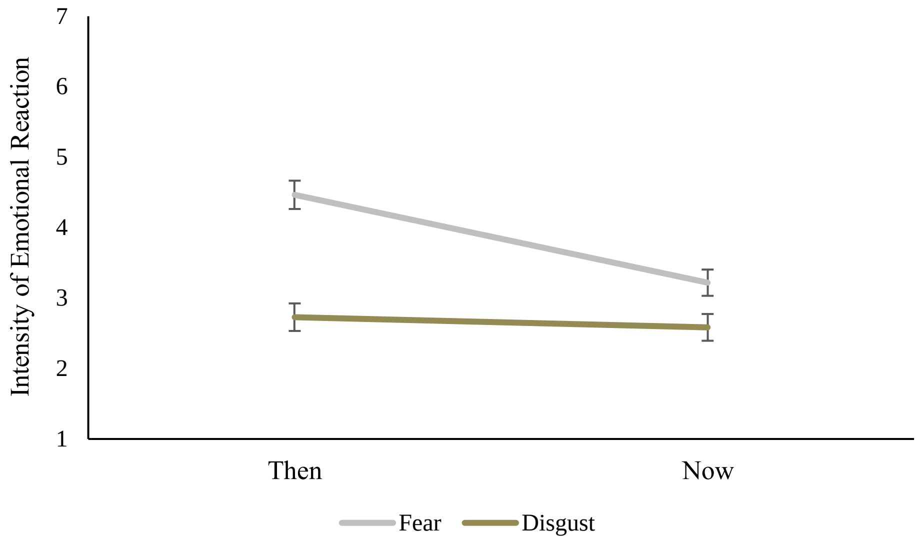
Inferential Statistics

Recall our research question: *Do disgust reactions to a recent traumatic event persist in memory to a greater extent than fear reactions?* Consistent with the fading affect literature (Walker & Skowronski, 2009), people reported experiencing more intense disgust and fear reactions *at the time the event occurred* (i.e., then) compared to when thinking about the event at present (i.e., now). Simple contrasts revealed statistically significant differences between ‘then’ and ‘now’ disgust reactions (M_{diff} = 0.1; 95% CI [0.03, 0.3], p = .015; η_p^2 = .01), and ‘then’ and ‘now’ fear reactions (M_{diff} = 1.2; 95% CI [1.1, 1.4], p < .001; η_p^2 = .32). Put differently, a two-way repeated measures ANOVA revealed a statistically significant interaction between time (i.e., then, now) and event-related emotion (i.e., disgust, fear), $F(1, 470) = 136.50$, p < .001, η_p^2 = .23. As hypothesised, whilst both emotions faded in intensity from ‘then’ to ‘now’, this effect was small for disgust but large for fear, indicating a differential fading emotion bias (see Figure 6.1). This pattern suggests greater persistence in recalled disgust compared to fear reactions following a recent traumatic/stressful event.

[25] Some participants (n = 40) reported their most traumatic/stressful event occurred over six months ago (from six and a half months to two years). We re-analyzed our results excluding these participants and the pattern of results remained consistent (see Supplementary Table S6.3).

Figure 6.1

Interaction between Event-Related Mean 'Then' and 'Now' Intensity Scores by Emotional Reaction Category (Disgust, Fear) with 95% Confidence Intervals



Next, we wondered whether the difference between the 'then' and 'now' disgust and fear reactions related to PTS symptom level. When we added PTS symptoms as a covariate[26] to the two-way repeated measures ANOVA above, the interaction between time and event-related emotion remained significant: $F(1, 469) = 48.21$, $p < .001$, $\eta_p^2 = .09$. Thus, the differential fading bias between disgust and fear was not explained by the effect of PTS symptom severity. Rather, disgust and fear similarly faded from 'then' to 'now' regardless of participants' PTS symptom severity.

We also wondered whether the difference between the 'then' and 'now' disgust and fear reactions related to days since the traumatic event occurred. Here we instead added days since the traumatic event occurred as a covariate to the two-way repeated measures ANOVA above. The interaction between time and event-related emotion remained significant (*F*(1,

[26] Inferential statistics for all Study 4a and Study 4b three-way ANCOVA interactions (i.e., Time*Emotion*PTS symptoms and Time*Emotion*Days since the event) appear in Supplementary Table S6.4.

432) = 53.67, $p < .001$, $\eta_p^2 = .11$), indicating the differential fading bias between disgust and fear was not explained by how long ago participants' traumatic event occurred.

Discussion

We aimed to determine whether disgust reactions to a recent traumatic event persisted in memory to a greater extent than fear reactions. As predicted—and, consistent with the fading affect literature (Walker & Skowronski, 2009)—participants reported more intense disgust and fear 'then' reactions (i.e., how they remembered feeling at the time the event occurred) compared to at present. This fading effect was stronger for fear than disgust reactions. PTS symptom severity and time since the traumatic event occurred were not related to the differential fading of disgust and fear reactions. But our main finding—that disgust faded to a lesser extent than fear—extends the fading affect literature by suggesting that discrete negative emotions may fade at different rates, providing preliminary evidence that disgust and fear fade differently.

Study 4a has two important limitations. First, the final event category listed in the THS asks participants if they experienced "*some other event that made you feel scared, helpless or horrified*". The presence of the word "scared" (which is synonymous to "fear") may have created demand effects and/or inadvertently led participants to bring to mind a fear-inducing event and/or rate more intense fear reactions than what they otherwise would have (i.e., without seeing the word "scared"). We addressed this limitation in Study 4b by removing this event category from the THS.

Second, due to our cross-sectional design, participants retrospectively recalled emotions they experienced during their traumatic event (which occurred up to six-months prior to participation). However, we know memory for past emotion—and autobiographical experiences generally—is subject to forgetting and bias over time (Safer et al., 2002). For example, it is possible that participants used their initial reaction response (to either 'then' or 'now', which were presented in a counterbalanced order) as an anchor to inform their response on the next rating. To examine this possibility, we ran independent samples *t*-tests to compare the effect of emotional reactions questionnaire counterbalance order ('then' first, 'now' first) on the intensity of disgust and fear ratings in both studies. We found no significant differences between disgust and fear ('then' and 'now') ratings (see Supplementary Table S6.8). Therefore, participants did not appear to use their initial response ('then' or 'now) to inform their subsequent response.

One relevant bias that may have influenced participants' 'then' emotion ratings is the *memory-experience gap*, whereby people overestimate the intensity of past emotions and symptoms in memory, relative to estimates taken when these emotions/symptoms occurred (e.g., Miron-Shatz et al., 2009). But appraisal theories of emotion suggest people may not always overestimate past emotions. Rather, the direction in which people misremember the intensity of past emotions depends on their current appraisals (e.g., feelings, goals) of the emotion-eliciting event (Levine, 1997). When problems related to a past event have been resolved, people tend to underestimate (or forget) past emotional intensity for that event, whereas when problems related to that event are ongoing, unresolved and/or have implications for the future, people tend to overestimate past emotion (Levine et al., 2009). In line with this idea, Nahleen et al. (2019) found participants whose PTS symptoms had reduced over six-months underestimated their previous symptom severity (i.e., they recalled experiencing fewer PTS symptoms than what they had initially reported six months earlier), and vice versa for participants who demonstrated severe PTS symptoms over time. Therefore—despite our attempt to limit such memory biases by only asking participants to report a recent event—it is plausible participants remembered their 'then' disgust and fear emotions as more/less intense than they were. We addressed this limitation in Study 4b by examining whether disgust's smaller fading trajectory—or, persistence—relative to fear replicates over time, using a longitudinal design.

Study 4b

In Study 4b[27] participants reported their disgust and fear reactions over two sessions: the first session replicated Study 4a and the second session occurred after a three-month delay, where participants only provided current ('now') emotion ratings. We expected to replicate Study 4a's finding—that trauma-related disgust reactions faded at a smaller rate than fear reactions—in both a cross-sectional ('then' and 'now' from Time 1) and longitudinal ('now' from Time 1 and 'now' from Time 2) comparison.

Method

Participants

In Study 4a we found a large two-way within-subjects effect (η_p^2 = .23; or, *d* = 1.09) for the differential emotional fading of disgust vs. fear reactions. We used a smaller effect size to determine Study 4b's sample size because Brysbaert (2019) suggests psychological research findings start to have practical and/or theoretical relevance at a medium effect size (i.e., *d* = 0.40), and because using uncorrected effect sizes from prior studies can lead to underpowered estimates of *N* (Anderson et al., 2017). Thus, we based our target *n* = 110 on Brysbaert's recommendation for a medium effect in a 2 x 2 within-subjects design (our main analysis of interest) and recruited an additional 50 participants (target *N* = 160) to account for potential attrition at Time 2 (i.e., after a three-month delay; Nahleen et al., 2019).

We recruited 166 participants for Time 1 but excluded six participants: four provided a traumatic event description consistent with bots/farmers or thoughtless responding (e.g., "ok"), one did not provide a description or title for their event (i.e., responded "N/A"), and

[27] As an exploratory interest, we wondered whether our participants exhibited the typical fading affect bias found in the existing literature (e.g., Walker & Skowronski, 2009), but in the context of comparing positive and negative *emotions* rather than affect. These data are beyond the scope of the current paper and therefore we report them in supplementary material.

one reported their event occurred more than three months ago. Of the 160 participants who successfully completed Time 1, 132 completed Time 2 (following a three-month delay). We excluded 22 participants: 10 reported they forgot what traumatic event they described at Time 1, 10 described a traumatic event that clearly referred to a different event than they described at Time 1, and one did not provide an event description and therefore, we could not conclude that they responded in response to the same event as at Time 1. To reach our target sample (n = 110), we departed from our pre-registered requirement that participants complete Time 2 within three days following the three-month delay. Ninety-nine (90%) participants completed Time 2 within three days, five participants within four days, three participants within five days, one participant within seven days, one participant within eight days, and one participant within 12 days.

Our final sample comprised 160 participants who completed only Time 1 and 110 participants who completed the entire study[28]. The 110 participants ranged from 22–71 years (M = 42.6, SD = 11.6); most were women (59.1%, men = 38.2%, non-binary = 1.8%, prefer not to say = 0.9%). Most were American (95.5%, Malaysian = 0.9%) and some provided their ethnicity instead of nationality (e.g., “White” and/or “Caucasian”, 2.7%; “Latino”, 0.9%).

Materials

Trauma History Screen (THS; Carlson et al., 2011). We made some minor changes to the THS, relative to Study 4a. We adapted the THS to measure exposure in the last three months to ensure our Time 2 data—following a three-month delay—captured trauma exposure in the last six months (which reflects Study 4a’s time constraints). Because retrospectively calculating how many days/months since their event occurred may be cognitively taxing (and prone to error), participants instead indicated the date their event occurred on a calendar. Furthermore, we removed an item referring explicitly to fear

[28] We use n = 160 to analyze our cross-sectional replication of Study 4a and n = 110 for all other analyses.

responses (*some other event that made you feel scared, helpless or horrified*). Participants also provided a short title for their traumatic/stressful event, which was then shown to them during Time 2 of the study to remind them of their event (and to ensure their responses to measures at Time 2 were in relation to the same event they described during Time 1).

Emotional reactions. As in Study 4a, except participants rated how intensely they felt/feel eight discrete emotions: four negative (disgust, fear, anger, sadness) and four positive (compassion, relaxed, hope, strong). In line with the existing fading affect literature (Skowronski et al., 2014), participants also rated affect (i.e., how unpleasant or pleasant they felt/feel; *1 = extremely unpleasant, 7 = extremely pleasant*) in response to the traumatic event. Inferential statistics for changes in affect, average negative emotion levels (i.e., the four negative emotions averaged into a single score) and average positive emotion levels (i.e., the four positive emotions averaged into a single score) over time are reported in supplementary material.

Posttraumatic Stress Disorder Checklist (PCL-5; Weathers et al., 2013). As in Study 4a (current study Time 1: $\alpha = .96$, Time 2: $\alpha = .96$).

Procedure

The procedure during Time 1 was the same as in Study 4a. Three months later, we invited participants to another survey (Time 2). First, we showed participants the title they provided for their stressful/traumatic event at Time 1, to remind them of that event. Next, they answered the emotional reactions questionnaire (only ‘now’ questions) in relation to this event, and then the PCL-5. Finally, participants were asked to re-describe their stressful/traumatic event from Time 1 and indicate whether they did or did not (e.g., due to forgetting) provide responses in relation to the same event at both time points, then participants were debriefed. Participants received $0.90USD for Time 1 (~9 mins) and $0.60USD for Time 2 (~4 mins).

Results

Descriptive Statistics

Table 6.1 displays descriptive statistics for variables we used in the main analyses. Consistent with Study 4a, event-related emotional reactions were low-moderate in intensity overall; disgust reactions were less intense than fear reactions. On average, people at Time 1 rated affect toward their traumatic event as unpleasant (M = 1.9, SD = 1.3 for ‘then’; M = 3.3, SD = 1.6 for ‘now’), but typically rated affect toward their event at Time 2 as neutral (i.e., M = 3.9, SD = 1.4; near the bipolar affect scale’s midpoint of 4). On average, participants reported subthreshold PTSD symptom levels, based on the PCL-5 cut-off (31; Ashbaugh et al., 2016). According to this cut-off, 28.8% of the sample at Time 1 (n = 46) and 21.8% of the sample at Time 2 (n = 24) were PTSD-probable (83.3% of these Time 2 PTSD-probable participants were PTSD-probable across both time points, n = 20). On average, participants’ PTS symptom scores remained relatively stable over time (overall slightly decreasing, though these changes were variable across participants; SD = 11.1).

Table 6.2

Descriptive statistics for main variables in Study 4b

Measures	*Scale*	*Range*	*M (SD)*
Time 1			
Event-related disgust (‘then’)	1 – 7	1 – 7	2.6 (2.1)
Event-related disgust (‘now’)	1 – 7	1 – 7	2.3 (1.8)
Event-related fear (‘then’)	1 – 7	1 – 7	4.3 (2.1)
Event-related fear (‘now’)	1 – 7	1 – 7	2.8 (1.9)
PCL-5 total	0 – 80	0 – 67	21.6 (17.4)
Time 2			
Event-related disgust (‘now’)	1 – 7	1 – 7	2.1 (1.7)
Event-related fear (‘now’)	1 – 7	1 – 7	2.5 (1.9)
PCL-5 total	0 – 80	0 – 52	16.4 (14.7)
PCL-5 change from Time 1 to Time 2	-80 – 80	-34 – 35	3.6 (11.1)

Note. N = 160 for Time 1 measures; n = 110 for Time 2 measures; PCL-5 = Posttraumatic Stress Disorder Checklist; We calculated PTS symptom change by subtracting Time 2 PTS symptom scores from Time 1 PTS symptom scores (positive scores indicate a decrease in PTS symptoms from Time 1 to Time 2, negative scores indicate an increase in PTS symptoms from Time 1 to Time 2, higher scores indicate greater change in PTS symptoms between Time 1 and Time 2.

As for Study 4a, we examined disgust and fear emotional reaction scores separated by stressful/traumatic event type (Supplementary Tables S6.5 and S6.6). Similar to Study 4a, people experienced similarly intense disgust and fear reactions for the following event types: ‘forced or made to have sexual contact’, ‘attack with a gun, knife or weapon’, ‘during military service – seeing something horrible or being badly scared’, ‘suddenly abandoned by spouse, partner, parent, or family' and 'relationship issues'. However, these five events only comprised 8.2% of participants who completed both study timepoints (n = 9 out of N = 110) and 13.1% of total participants' (n = 21 out of N = 160) worst events. For most other event types, people generally experienced less intense disgust relative to fear reactions. Next, we examined disgust and fear emotional reaction scores separated by time since the traumatic event occurred (Supplementary Table S6.7). Both number of participants and emotional intensity ratings were similarly dispersed across each monthly increment.

Inferential Statistics

Cross sectional comparisons. Recall our research question: *Do disgust reactions to a recent traumatic persist in memory to a greater extent than fear reactions?* First, we examined Time 1 cross-sectional 'then' and 'now' emotional reaction responses. Consistent with Study 4a and the fading affect literature (Walker & Skowronski, 2009), people reported experiencing more intense disgust and fear reactions *at the time the event occurred* (i.e., then) compared to when thinking about the event at present (i.e., now). Simple contrasts revealed statistically significant differences between 'then' and 'now' disgust reactions (M_{diff} = 0.3; 95% CI [0.1, 0.5], p = .004; η_p^2 = .05), and 'then' and 'now' fear reactions (M_{diff} = 1.5; 95% CI [1.2, 1.8], p < .001; η_p^2 = .39). Put differently, a two-way repeated measures ANOVA revealed a statistically significant interaction between time (i.e., then, now) and event-related emotion (i.e., disgust, fear), $F(1, 159) = 46.32$, p < .001, η_p^2 = .23. As hypothesised (and similar to Study 4a's results), whilst both emotions faded in intensity from 'then' to 'now', this effect was small-to-moderate for disgust but large for fear (see Figure 6.2[29]). This pattern suggests greater persistence in remembered disgust compared to fear reactions following a recent traumatic/stressful event.

[29] This figure represents participants who completed both timepoints of the study (n = 110). See Supplementary Figure S6.1 for all participants who provided Time 1 (then/now) responses (N = 160).

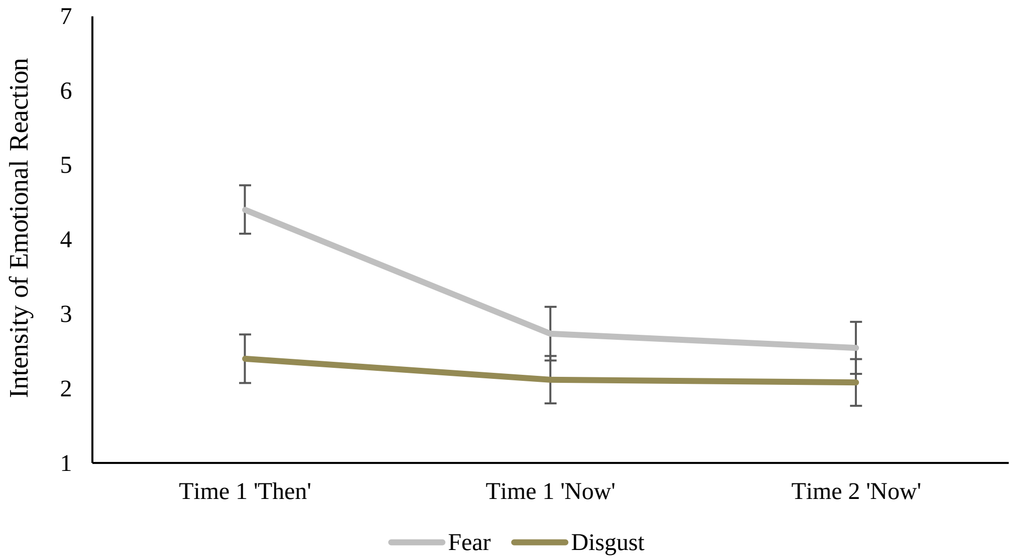
We then wondered whether any difference in fading of disgust and fear reactions related to PTS symptoms. When we added PTS symptoms at Time 1 as a covariate to the two-way repeated measures ANOVA above, the interaction between time and event-related emotion remained significant: $F(1, 158) = 34.23$, $p < .001$, $\eta_p^2 = .18$. Therefore, the differential fading emotion bias between disgust and fear was not explained by the effect of PTS symptom severity at Time 1, consistent with Study 4a.

We also wondered whether the difference between the 'then' and 'now' disgust and fear reactions related to days since the traumatic event occurred. We ran a two-way repeated measures ANCOVA, with days since the traumatic event occurred as a covariate. Consistent with Study 4a, the interaction between time and event-related emotion remained significant ($F(1, 158) = 8.80$, $p = .003$, $\eta_p^2 = .05$), which indicated the differential fading bias between disgust and fear was not explained by how long ago participants' traumatic event occurred.

Longitudinal comparisons. Next, we turn to our other key interest in whether disgust reactions to a recent traumatic also persist to a greater extent than fear reactions when measured *longitudinally*, over a three-month delay. We examined this possibility by comparing the 'now' ratings from Time 1 and Time 2. In contrast to our cross-sectional results, people reported experiencing similarly intense disgust and fear reactions from Time 1 to Time 2 (i.e., over a three-month delay). Simple contrasts revealed non-significant differences between Time 1 and Time 2 disgust reactions ($M_{diff} = 0.04$; 95% CI [-0.2, 0.3], $p = .80$; $\eta_p^2 = .001$), and Time 1 and Time 2 fear reactions ($M_{diff} = 0.2$; 95% CI [-0.1, 0.5], $p = .27$; $\eta_p^2 = .01$). Put differently, a two-way repeated measures ANOVA revealed a non-significant interaction between time (i.e., Time 1, Time 2) and event-related emotion (i.e., disgust, fear), $F(1, 109) = 0.66$, $p = .42$, $\eta_p^2 = .006$. This pattern suggests disgust and fear reactions to a recent traumatic event both persisted over time. Because we did not find a significant interaction between time and event-related emotion, we did not analyze change in PTS symptom severity over time, or days since the traumatic event occurred, as covariates.

Figure 6.2

Interactions between Event-Related Time 1 'Then' and 'Now' Intensity Scores, and Time 1 'Now' and Time 2 'Now' Intensity Scores, by Emotional Reaction Category (Disgust, Fear) with 95% Confidence Intervals



Summary of Results

Study 4b aimed to determine whether disgust's persistence in memory—relative to fear—in relation to a recent traumatic event replicated cross-sectionally and longitudinally. As predicted, participants reported more intense disgust and fear 'then' compared to 'now' ratings at Time 1, and this effect was stronger for fear than disgust reactions. Thus, consistent with Study 4a's findings, disgust reactions faded to a smaller extent—or persisted more—than fear reactions from 'then' to 'now' in the first study session. However, this differential fading emotion effect between disgust and fear was not maintained from Time 1 to Time 2. Instead, disgust and fear reactions *both* persisted over time, to a comparable extent.

General Discussion

We aimed to determine whether disgust reactions to a recent traumatic event persisted in memory to a greater extent than fear reactions, using two methodological designs: cross-sectional (within a single session) and longitudinal (across two sessions, three-months apart). Our main findings were mixed. When participants recalled how they felt at the time their traumatic event occurred ('then') vs. in the present moment ('now'), their disgust and fear reactions were more intense for 'then' vs. 'now' (suggesting the reactions faded in intensity), though this difference was smaller for disgust than fear. PTS symptom severity and time since the traumatic event occurred did not explain these main findings. But participants' disgust and fear reactions did not fade in intensity over a three-month delay: both emotions similarly persisted over time. Our cross-sectional main findings are consistent with existing memory research suggesting disgust is similarly (i.e., Matson et al., 2023)—if not more (e.g., Chapman et al., 2013; Moeck et al., 2021)—memorable than fear.

When we asked participants, at a single-time point, to rate how disgusted and frightened they felt at the time their traumatic event occurred ('then') relative to when currently thinking about the event ('now') we found, across two samples, that disgust persisted in memory to a greater extent than fear. Here, participants' memory of their past ("then") trauma-related disgust and fear reactions may have been influenced—or, biased—by their *current* disgust and fear reactions (regardless of which emotions they rated first; Levine, 1997). These biases are informative when considering a person's perception of their past and current emotional experience. Walker and Skowronski (2009) describe the fading affect bias as an *adaptive reappraisal*, where people's memories of their past event-related emotions, and their perceptions of their current event-related emotions, are meaningfully linked to their present outlook on life. Thus, perhaps, when responding to the cross-sectional questions, participants' tendency to remember stronger feelings of fear in the past ('then') compared to 'now' suggests this emotion is no longer relevant/impacting them. In contrast, participants' tendency to remember a similar intensity of both past and current feelings of disgust suggests a lack of resolution for this emotion. Indeed, like other negative emotions (e.g., fear), disgust functions to signal threat (i.e., contamination). However, disgust's additional evaluative properties mean that disgust reactions persist once the threat has been removed (Olatunji & Sawchuk, 2005). For example, people feel disgust toward—and refuse to drink from—a thoroughly sanitised glass that once held faeces, despite this object no longer having contaminating properties (Rozin & Nemeroff, 1990). Participants' consistent ratings of disgust are in line with the idea that disgust is a memorable emotion (or, that feelings of disgust are difficult to resolve or eliminate). However, our data cannot confirm this possibility. Thus, future research should confirm the directionality of such memory biases by comparing retrospective 'then' to actual 'then' disgust and fear reactions (i.e., collecting 'now' emotion ratings at Time 1, and 'then' emotion ratings—indexed to the ratings they gave at Time 1—at a later timepoint).

Our longitudinal data suggest that disgust and fear do not differ in their persistence between three- and six-months following trauma. An alternative explanation is that trauma-related disgust reactions do persist more than fear reactions (as suggested by our cross-sectional results), but we could not detect this differential fading emotion bias longitudinally (i.e., from Time 1 to Time 2) because participants' fear reactions had already faded since their traumatic event occurred. Thus, future research should examine the disgust and fear fading trajectory more closely by measuring these emotions across numerous timepoints (e.g., using experience sampling methods).

Our results have practical implications. When disgust reactions occur following a traumatic event, they may be resistant to the typical emotion fading trajectory seen for other autobiographical experiences (i.e., non-traumatic events; Skowronski et al., 2014). Yet, disgust has historically been neglected as a PTSD-relevant emotion, despite its presence among various trauma populations (Jones et al., 2020). Our cross-sectional results provide clinically useful insight into why disgust may be particularly ‘sticky’ in memory relative to fear (regardless of whether or how the emotion actually fades over time) and in turn, why disgust may be a difficult emotion to treat in PTSD. Indeed, disgust is resistant to exposure therapy, a commonly endorsed PTSD treatment approach that aims to habituate (i.e., reduce a learned emotional response’s intensity and frequency)—or, encourage fading of—trauma-relevant emotions (Olatunji et al., 2007b). Specifically, disgust reactions fade at a significantly slower rate than fear reactions during exposure therapy (Harned et al., 2015). Disgust’s resistance to PTSD treatment reflects disgust’s durability, but also highlights an issue where—even in situations where disgust is the dominant emotion to a trauma—disgust may not be explicitly targeted in these treatments as intensively as fear (Matson et al., 2023).

Our studies have limitations. First, participants’ memory of their past emotions may not accurately reflect how they truly felt when the event occurred. To confirm the accuracy of participants’ memory of their peritraumatic emotions, participants would also have had to provide trauma-related disgust and fear ratings soon after the event occurred (i.e., in the hours/days following the event), which was beyond the scope of the present studies. Future research could obtain such disgust and fear ratings by recruiting participants at locations typically frequented following traumatic experiences (e.g., hospitals). Nevertheless, understanding how people perceive their past emotional state (by asking them to retrospectively recall past emotions) is important; in clinical settings, clinicians rely on clients’ retrospective reports of their emotional state (among other symptoms) to diagnose mental health disorders (Nahleen et al., 2019). Thus, people’s subjective recall of their past (and current) emotional state plays a key role in maintaining—or, impairing—wellbeing.

Second, participants' disgust and fear 'then' (i.e., baseline) reactions were not equally intense; disgust reactions were low in intensity and fear reactions were moderately intense. Therefore, perhaps disgust appeared to persist because there was limited capacity for it to fade over time from initial low intensity (i.e., floor effects). These low disgust ratings are somewhat unsurprising given we measured a broad range of traumatic events. Disgust may only occur in response to certain traumatic events (e.g., sexual assault, combat) whereas—consistent with the emphasis on fear seen in PTSD theoretical models and diagnostic criteria (Badour & Feldner, 2018)—fear occurs during/following a broader range of traumatic events. Furthermore, participants commonly reported grief and loss ('*sudden death of a close family member or friend*') across both studies, where disgust is not typically a primary response. Perhaps disgust fades similarly to fear when participants' baseline disgust levels are also moderately intense. A minority of participants (Study 4a: 11.9%; Study 4b: 8.2% both timepoints, 13.1% Time 1 only) reported traumatic events typically associated with intense disgust and fear reactions (e.g., interpersonal violence; Badour et al., 2012). We re-ran our main analysis using Study 4a's subsample[30] (*n* = 55) to examine whether disgust fades like fear when these emotions are similarly (moderately) intense at baseline. We replicated our main cross-sectional findings (see Supplementary Table S6.9 and Supplementary Figure S6.2): disgust faded from 'then' to 'now' to a significantly smaller extent than fear did. These results provide compelling evidence for disgust's persistence in memory. Future research should compare disgust and fear's retrospective (i.e., subjective/cross-sectional) and longitudinal persistence—or, fading—for traumatic events known to elicit intense disgust and fear reactions (e.g., sexual assault; Badour et al., 2013c).

[30] We conducted a G*Power sensitivity analysis using *n* = 55 with 80% power (at $p < .05$) and four measurement levels, which revealed this sample was appropriately powered to detect a medium effect ($\eta_p^2 = .06$). We did not re-run our main analysis using Study 4b's subsample due to smaller, underpowered sample sizes (*n* = 9 who participated at both timepoints, *n* = 22 who only participated during Time 1).

Disgust is a durable and a multifaceted emotion. The present studies' cross-sectional results provide further evidence for disgust's memorability. Specifically, disgust reactions are similarly—if not more—persistent in memory when compared to fear reactions following a recent trauma. Prolonged negative emotional reactions—like disgust and fear—to a traumatic event may increase a person's risk of developing and maintaining PTSD, particularly when they do not simultaneously experience an increase in positive resilience-based emotions.

Supplementary Materials

Supplementary Table S6.1

Study 4a descriptive statistics for key emotional reaction intensity variables among each traumatic/stressful event type (including n of participants who indicated that event type as their most stressful/traumatic event).

		Disgust Reactions		***Fear Reactions***	
Traumatic/Stressful Event Type (THS)	*n*	*Then M (SD) [Range]*	*Now M (SD) [Range]*	*Then M (SD) [Range]*	*Now M (SD) [Range]*
A. A really bad car, boat, train, or airplane accident	15	3.9 (2.1) [1–7]	3.8 (2.6) [1–7]	5.8 (1.3) [3–7]	4.0 (2.5) [1–7]
B. A really bad accident at work or home	8	3.3 (1.8) [1–6]	2.8 (1.6) [1–5]	4.4 (1.7) [2–7]	3.4 (1.6) [1–5]
C. A hurricane, flood, earthquake, tornado, or fire	15	1.9 (1.2) [1–5]	2.1 (1.9) [1–7]	5.8 (1.1) [3–7]	3.3 (2.1) [1–7]
D. Hit or kicked hard enough to injure	12	4.8 (2.1) [1–7]	3.5 (2.5) [1–7]	4.4 (2.3) [1–7]	3.6 (2.6) [1–7]
E. Forced or made to have sexual contact	5	5.6 (1.9) [3–7]	5.2 (2.7) [1–7]	6.2 (1.3) [4–7]	4.4 (2.2) [1–7]
F. Attack with a gun, knife, or weapon	4	4.5 (2.5) [1–7]	6.0 (1.4) [4–7]	6.8 (0.5) [6–7]	4.8 (1.9) [2–6]
G. During military service – seeing something horrible or being badly scared	0	-	-	-	-
H. Sudden death of a close family member or friend	154	2.1 (1.9) [1–7]	2.0 (1.6) [1–7]	3.6 (2.3) [1–7]	2.8 (1.9) [1–7]
I. Seeing someone die suddenly or get badly hurt or killed	16	3.3 (2.7) [1–7]	2.8 (2.6) [1–7]	5.4 (1.9) [1–7]	3.8 (2.4) [1–7]

J. Some other sudden event that made you feel very scared, helpless, or horrified	34	3.7 (2.5) [1–7]	3.9 (2.6) [1–7]	5.8 (1.8) [1–7]	4.0 (2.1) [1–7]
K. Sudden move or loss of home and possessions	26	3.5 (1.8) [1–7]	3.3 (1.8) [1–7]	5.0 (1.8) [2–7]	3.7 (1.9) [1–7]
L. Suddenly abandoned by spouse, partner, parent, or family	14	4.2 (1.8) [1–7]	3.7 (1.9) [1–7]	4.9 (1.6) [2–7]	3.4 (1.7) [1–7]
M. *Non-sudden death of a close family member or friend*	8	1.1 (0.4) [1–2]	1.1 (0.4) [1–2]	1.8 (1.2) [1–4]	1.4 (0.7) [1–3]
N. *Stress or trauma in everyday activities*	*43*	2.6 (2.1) [1–7]	2.1 (1.8) [1–7]	4.1 (2.0) [1–7]	2.8 (1.8) [1–7]
O. *Health-related problems for subject or close other*	*37*	1.6 (1.4) [1–7]	1.6 (1.3) [1–7]	5.2 (2.2) [1–7]	3.8 (2.1) [1–7]
P. *COVID-19 Pandemic-related stressors (e.g., medical, psychological, practical)*	*59*	2.6 (2.0) [1–7]	2.6 (2.1) [1–7]	4.7 (2.2) [1–7]	3.3 (2.2) [1–7]
Q. *Relationship issues*	*21*	4.3 (2.5) [1–7]	4.1 (2.6) [1–7]	4.1 (2.2) [1–7]	2.8 (2.0) [1–7]

Note. Italicised events (M. – P.) are not event categories in the THS, but were created after coding event descriptions among participants who described their most ‘stressful’ (rather than ‘traumatic’) event from the last six months; *n* = participants who indicated that event type as their most stressful/traumatic event.

Supplementary Table S6.2

Study 4a descriptive statistics for key emotional reaction intensity variables among time since the traumatic event occurred (monthly increments).

		Disgust Reactions		***Fear Reactions***	
Time Since Event	*n*	*Then* *M (SD)*	*Now* *M (SD)*	*Then* *M (SD)*	*Now* *M (SD)*
0 – 30 Days (within 1 month)	79	2.7 (2.3)	2.5 (2.2)	4.6 (2.2)	3.4 (2.0)
31 – 60 Days (between 1 and 2 months)	61	2.4 (2.0)	2.2 (1.9)	4.5 (2.3)	3.4 (2.1)
61 – 90 Days (between 2 and 3 months)	67	2.8 (2.2)	2.7 (2.1)	4.2 (2.3)	3.2 (2.0)
91 – 120 Days (between 3 and 4 months)	74	2.5 (2.0)	2.3 (1.9)	4.6 (2.2)	3.3 (2.2)
121 – 150 Days (between 4 and 5 months)	75	2.9 (2.2)	3.0 (2.4)	4.8 (2.1)	3.1 (2.0)
151 – 180 Days (between 5 and 6 months)	75	2.8 (2.1)	2.3 (1.9)	4.0 (2.2)	2.9 (2.0)
181 – 1440 Days (6+ months)	40	3.0 (2.4)	3.2 (2.3)	4.4 (2.5)	3.4 (2.3)

Note. n = participants who indicated their most stressful/traumatic event occurred within the respective time period; Scale and range for all emotional reaction measures is 1—7.

Supplementary Table S6.3

Study 4a inferential statistics excluding participants (n = 40) who reported their event occurred more than six months ago.

Analysis	Inferential Statistic
Two-way repeated measures ANOVA (emotion: disgust, fear; time: then, now)	$F(1, 430) = 120.86$, $p < .001$, $\eta_p^2 = .22$
Simple contrast between 'then' and 'now' disgust reactions	$M_{\text{diff}} = 0.2$; 95% CI [0.05, 0.3], $p = .006$; $\eta_p^2 = .02$
Simple contrast between 'then' and 'now' fear reactions	$M_{\text{diff}} = 1.3$; 95% CI [1.1, 1.4], $p < .001$; $\eta_p^2 = .33$
PTS symptom severity added as a covariate to the two-way repeated measures ANOVA	$F(1, 429) = 41.78$, $p < .001$, $\eta_p^2 = .09$
Days since the event occurred severity added as a covariate to the two-way repeated measures ANOVA	$F(1, 429) = 23.02$, $p < .001$, $\eta_p^2 = .05$

Note. $n = 431$. All analyses revealed the same pattern of results as those reported in the main paper.

Supplementary Table S6.4

Inferential statistics for the three-way interactions from the ANCOVA analyses.

Analysis	Inferential Statistic
Study 4a	
Time * Emotion * PTS Symptoms	$F(1, 469) = 0.01$, $p = .91$, $\eta_p^2 = .00003$
Time * Emotion * Days since the event	$F(1, 467) = 0.24$, $p = .62$, $\eta_p^2 = .001$
Study 4b (Time 1 'then' and 'now' reactions)	
Time * Emotion * PTS Symptoms	$F(1, 158) = 4.00$, $p = .048$, $\eta_p^2 = .02$
Time * Emotion * Days since the event	$F(1, 158) = 0.17$, $p = .68$, $\eta_p^2 = .001$

Note. $N = 471$ in Study 4a; $N = 160$ in Study 4b.

Supplementary Table S6.5

Study 4b descriptive statistics for key emotional reaction intensity variables among each traumatic/stressful event type (including n of participants who indicated that event type as their most stressful/ traumatic event). N = 160 participants (all participants who completed Part 1 of Study 4b).

		Disgust Reactions		**Fear Reactions**	
Traumatic/Stressful Event Type (THS)	*n*	Then *M (SD)* [Range]	Now *M (SD)* [Range]	Then *M (SD)* [Range]	Now *M (SD)* [Range]
A. A really bad car, boat, train, or airplane accident	9	3.1 (2.1) [1–7]	2.2 (1.4) [1–5]	6.0 (1.5) [3–7]	4.2 (2.3) [1–7]
B. A really bad accident at work or home	7	3.1 (1.8) [1–6]	2.6 (1.8) [1–6]	5.4 (1.4) [3–7]	4.0 (1.5) [2–6]
C. A hurricane, flood, earthquake, tornado, or fire	5	1.4 (0.9) [1–3]	1.2 (0.4) [1–2]	4.6 (2.3) [1–7]	3.6 (2.1) [1–6]
D. Hit or kicked hard enough to injure	2	3.5 (3.5) [1–6]	2.5 (2.1) [1–4]	5.5 (2.1) [4–7]	1.5 (0.7) [1–2]
E. Forced or made to have sexual contact	1	7.0 (-) [7]	7.0 (-) [7]	6.0 (-) [6]	1.0 (-) [1]
F. Attack with a gun, knife, or weapon	1	7.0 (-) [7]	7.0 (-) [7]	6.0 (-) [6]	3.0 (-) [3]
G. During military service – seeing something horrible or being badly scared	1	5.0 (-) [5]	4.0 (-) [4]	6.0 (-) [6]	3.0 (-) [3]
H. Sudden death of a close family member or friend	40	1.5 (1.2) [1–6]	1.6 (1.2) [1–5]	3.3 (2.3) [1–7]	2.1 (1.7) [1–]
I. Seeing someone die suddenly or get badly hurt or killed	7	2.4 (2.3) [1–7]	2.1 (2.2) [1–7]	5.1 (1.6) [2–7]	3.7 (1.4) [2–6]
K. Sudden move or loss of home and possessions	7	3.0 (2.3) [1–7]	2.6 (2.1) [1–6]	5.1 (1.9) [3–7]	3.1 (2.0) [1–7]
L. Suddenly abandoned by spouse, partner, parent, or family	11	5.1 (1.9) [1–7]	3.7 (2.1) [1–7]	4.5 (1.9) [1–7]	2.8 (1.7) [1–5]
M. *Non-sudden death of a close family member or friend*	1	1.0 (-) [1]	1.0 (-) [1]	1.0 (-) [1]	1.0 (-) [1]

N. *Stress or trauma in everyday activities*	*10*	3.4 (2.8) [1–7]	2.7 (2.6) [1–7]	4.4 (2.5) [1–7]	2.4 (2.2) [1–7]
O. *Health-related problems for subject or close other*	*27*	2.2 (2.0) [1–7]	1.9 (1.5) [1–6]	4.9 (1.8) [2–7]	2.9 (1.9) [1–7]
P. *Relationship issues for subject or close other*	*7*	2.9 (2.3) [1–7]	2.6 (2.1) [1–6]	3.1 (2.1) [1–7]	3.3 (2.5) [1–7]
Q. *Financial stress for subject or close other*	*10*	2.1 (2.1) [1–7]	2.2 (2.3) [1–7]	4.8 (2.3) [1–7]	3.2 (2.1) [1–7]
R. *Job-related stress for subject or close other*	*14*	3.0 (1.7) [1–6]	2.9 (1.7) [1–6]	3.3 (1.6) [1–6]	2.9 (1.9) [1–6]

Note. Italicised events (M. – R.) are not event categories in the THS, but were created after coding event descriptions among participants who described their most ‘stressful’ (rather than ‘traumatic’) event from the last six months; *n* = participants who indicated that event type as their most stressful/traumatic event.

Supplementary Table S6.6

Study 4b descriptive statistics for key emotional reaction intensity variables among each traumatic/stressful event type (including n of participants who indicated that event type as their most stressful/traumatic event). N = 110 participants (i.e., only participants who completed both Part 1 and Part 2 of Study 4b).

		Disgust Reactions			***Fear Reactions***		
Traumatic/Stressful Event Type (THS)	*n*	T1 Then *M (SD)* [Range]	T1 Now *M (SD)* [Range]	T2 Now *M (SD)* [Range]	T1 Then *M (SD)* [Range]	T1 Now *M (SD)* [Range]	T2 Now *M (SD)* [Range]
A. A really bad car, boat, train, or airplane accident	9	3.1 (2.1) [1–7]	2.2 (1.4) [1–5]	3.4 (2.6) [1–7]	6.0 (1.5) [3–7]	4.2 (2.3) [1–7]	3.8 (2.7) [1–7]
B. A really bad accident at work or home	4	4.3 (1.3) [3–6]	3.3 (2.2) [1–6]	2.8 (1.7) [1–5]	6.3 (1.0) [5–7]	5.0 (0.8) [4–6]	5.0 (1.6) [3–7]
C. A hurricane, flood, earthquake, tornado, or fire	5	1.4 (0.9) [1–3]	1.2 (0.4) [1–2]	1.6 (0.9) [1–3]	4.6 (2.3) [1–7]	3.6 (2.1) [1–6]	1.6 (0.9) [1–3]
D. Hit or kicked hard enough to injure	1	1.0 (-) [1]	1.0 (-) [1]	1.0 (-) [1]	7.0 (-) [7]	1.0 (-) [1]	3.0 (-) [3]
E. Forced or made to have sexual contact	1	7.0 (-) [7]	7.0 (-) [7]	2.0 (-) [2]	6.0 (-) [6]	1.0 (-) [1]	2.0 (-) [2]
F. Attack with a gun, knife, or weapon	1	7.0 (-) [7]	7.0 (-) [7]	1.0 (-) [1]	6.0 (-) [6]	3.0 (-) [3]	1.0 (-) [1]
G. During military service – seeing something horrible or being badly scared	1	5.0 (-) [5]	4.0 (-) [4]	3.0 (-) [3]	6.0 (-) [6]	3.0 (-) [3]	3.0 (-) [3]
H. Sudden death of a close family member or friend	27	1.4 (1.0) [1–6]	1.5 (1.0) [1–4]	1.4 (1.0) [1–5]	3.0 (2.1) [1–7]	1.7 (1.1) [1–5]	1.5 (1.1) [1–6]
I. Seeing someone die suddenly or get badly hurt or killed	3	2.3 (1.5) [1–4]	1.7 (0.6) [1–2]	2.3 (1.5) [1–4]	5.7 (0.6) [5–6]	4.0 (1.7) [3–6]	1.3 (0.6) [1–2]

K. Sudden move or loss of home and possessions	6	2.7 (2.3) [1–7]	2.7 (2.3) [1–6]	2.7 (1.9) [1–5]	4.8 (1.8) [3–7]	3.2 (2.2) [1–7]	4.5 (2.3) [2–7]
L. Suddenly abandoned by spouse, partner, parent, or family	4	4.8 (2.9) [1–7]	4.0 (1.6) [2–6]	3.5 (2.4) [1–6]	5.8 (1.0) [5–7]	3.8 (1.9) [1–5]	3.3 (1.7) [1–5]
M. *Non-sudden death of a close family member or friend*	0	-	-	-	-	-	-
N. *Stress or trauma in everyday activities*	*5*	2.0 (2.2) [1–6]	1.2 (0.4) [1–2]	2.8 (2.2) [1–6]	4.2 (2.9) [1–7]	1.2 (0.4) [1–2]	2.6 (1.9) [1–6]
O. *Health-related problems for subject or close other*	*21*	2.2 (2.0) [1–7]	1.8 (1.5) [1–6]	1.5 (1.0) [1–4]	4.8 (1.9) [2–7]	2.8 (2.0) [1–7]	2.9 (1.7) [1–7]
P. *Relationship issues for subject or close other*	*2*	3.0 (1.4) [2–4]	2.5 (2.1) [1–4]	1.0 (-) [1]	3.5 (0.7) [3–4]	2.5 (2.1) [1–4]	1.5 (0.7) [1–2]
Q. *Financial stress for subject or close other*	*8*	2.4 (2.3) [1–7]	2.4 (2.6) [1–7]	2.6 (2.4) [1–7]	4.9 (2.5) [1–7]	3.1 (2.2) [1–7]	2.3 (2.1) [1–7]
R. *Job-related stress for subject or close other*	*12*	2.7 (1.5) [1–5]	2.5 (1.4) [1–5]	2.3 (1.7) [1–6]	3.3 (1.6) [1–6]	2.7 (1.8) [1–6]	2.5 (1.5) [1–5]

Note. Italicised events (M. – R.) are not event categories in the THS, but were created after coding event descriptions among participants who described their most ‘stressful’ (rather than ‘traumatic’) event from the last six months; *n* = participants who indicated that event type as their most stressful/traumatic event.

Supplementary Table S6.7

Study 4b descriptive statistics for key emotional reaction intensity variables among time since the traumatic event occurred (monthly increments), separated by all participants at Time 1 (n = 160) and Time 2 (n = 110).

		Disgust Reactions			***Fear Reactions***		
Time Since Event	*n*	T1 Then *M (SD)*	T1 Now *M (SD)*	T2 Now *M (SD)*	T1 Then *M (SD)*	T1 Now *M (SD)*	T2 Now *M (SD)*
Time 1							
1 – 30 Days (within 1 month)	50	2.5 (2.0)	2.2 (1.7)	-	4.3 (2.2)	3.0 (2.0)	-
31 – 60 Days (between 1 and 2 months)	71	2.6 (2.1)	2.1 (1.7)	-	4.2 (2.1)	2.7 (2.0)	-
61 – 92 Days (between 2 and 3 months)	39	2.7 (2.2)	2.7 (2.1)	-	4.6 (2.1)	2.9 (1.7)	-
Time 2							
93 – 120 Days (between 3 and 4 months)	27	2.3 (1.8)	2.0 (1.4)	2.0 (1.4)	4.5 (2.1)	3.0 (2.0)	2.8 (1.9)
121 – 150 Days (between 4 and 5 months)	33	2.4 (2.0)	1.9 (1.5)	2.1 (1.7)	4.4 (2.2)	2.7 (1.9)	2.5 (1.9)
151 – 185 Days (between 5 and 6 months)	15	2.4 (2.2)	2.6 (2.2)	2.1 (1.9)	4.4 (2.0)	2.5 (1.7)	2.3 (1.8)

Note. n = participants who indicated their most stressful/traumatic event occurred within the respective time period; Scale and range for all emotional reaction measures is 1—7 (except for T1 Now Fear ratings at 61 – 92 days, T1 Now Disgust ratings at 93 – 120 days, and T2 Now Fear ratings at 151 – 185 days, where the range is 1—6)..

Supplementary Table S6.8

Descriptive (Ms and (SDs)) and inferential statistics (independent samples t-tests) for counterbalance order (participants who gave 'then' emotion ratings first vs. participants who gave 'now' emotion ratings first) on disgust and fear 'then' and 'now' ratings.

	Gave 'then' ratings first	Gave 'now' ratings first					
	M (*SD*)	*M* (*SD*)	*df*	*t*	*p*	95% CI	Cohen's *d*
Study 4a							
'Then' disgust	2.9 (2.2)	2.6 (2.1)	467	1.46	.15	-0.10 – 0.68	0.14
'Now' disgust	2.7 (2.2)	2.5 (2.0)	455.98	0.83	.41	-0.22 – 0.54	0.08
'Then' fear	4.6 (2.2)	4.4 (2.2)	467	1.10	.28	-0.18 – 0.62	0.10
'Now' fear	3.2 (2.1)	3.2 (2.1)	467	0.05	.96	-0.36 – 0.38	0.005
Study 4b							
'Then' disgust	2.6 (2.1)	2.6 (2.1)	158	0.18	.86	-0.59 – 0.71	0.03
'Now' disgust	2.3 (1.8)	2.2 (1.9)	158	0.50	.62	-0.43 – 0.71	0.08
'Then' fear	4.4 (2.1)	4.3 (2.1)	158	0.38	.70	-0.54 – 0.80	0.06
'Now' fear	2.6 (1.8)	3.1 (2.0)	158	-1.94	.054	-1.18 – 0.01	-0.31

Note. *N* = 227 for Study 4a 'then' ratings first; *N* = 242 for Study 4a 'now' ratings first; *N* = 81 for Study 4b 'then' ratings first; *N* = 79 for Study 4b 'now' ratings first.

Supplementary Table S6.9

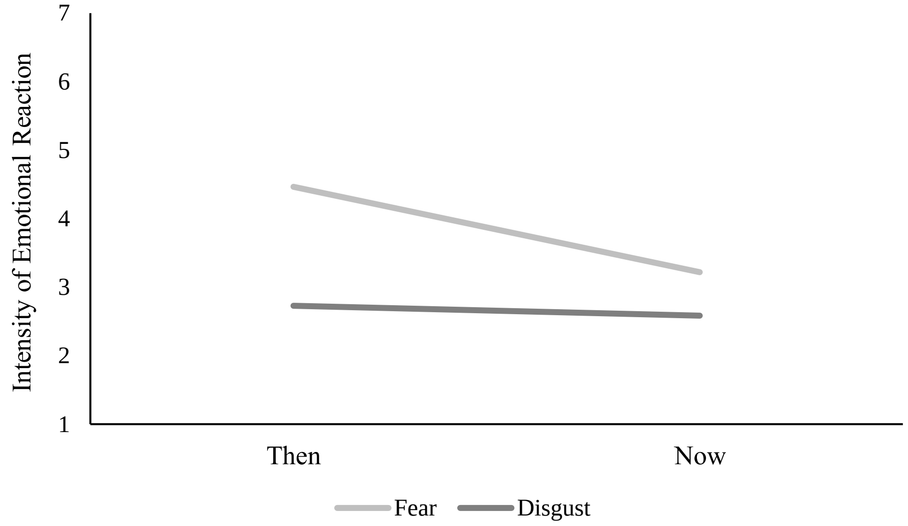
Descriptive and inferential statistics for 'then' and 'now' disgust and fear reactions to a recent trauma, using a subsample of participants (n = 55; Study 4a) who reported traumatic events associated with moderately intense ('then') disgust and fear reactions.

	Descriptive Statistics	
Emotion	Then *M (SD)*	*Now M (SD)*
Disgust	4.5 (2.2)	4.1 (2.4)
Fear	4.8 (2.1)	3.4 (2.1)

	Inferential Statistics					
Analysis	M_{diff}	*F*	*df*	*95% CI*	*p*	η_p^2
Two-way repeated measures ANOVA (emotion category: disgust, fear; time: then, now)	-	13.57	1, 55		< .001	.20
Simple contrasts for 'then' and 'now' disgust	0.4	-	-	0.008 – 0.8	.045	.07
Simple contrasts for 'then' and 'now' disgust	1.4	-	-	0.9 – 1.8	< .001	.40

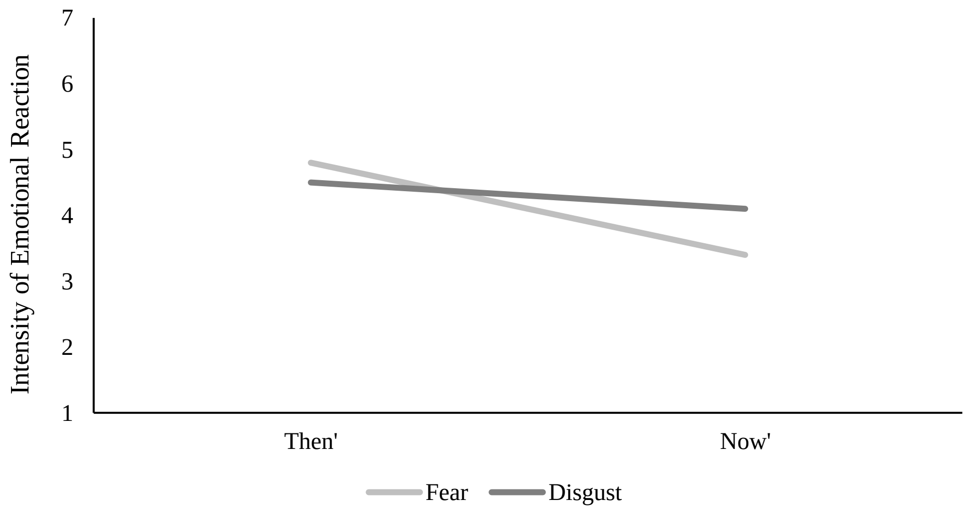
Supplementary Figure S6.1

Study 4b interaction between Event-Related Mean 'Then' and 'Now' Intensity Scores by Emotional Reaction Category (Disgust, Fear) for all participants who completed Time 1 (N = 160).



Supplementary Figure S6.2

Study 4a interaction between Event-Related Mean 'Then' and 'Now' Intensity Scores by Emotional Reaction Category (Disgust, Fear) for participants who experienced an event with on average, moderately intense disgust and fear reactions (N = 55).



Note. Event types were: 'hit or kicked hard enough to injure', 'forced or made to have sexual contact', 'attack with a gun, knife or weapon', 'suddenly abandoned by spouse, partner, parent, or family' and 'relationship issues'.

Study 4b Exploratory Analyses

To expand our exploratory interest regarding the fading affect bias, we wondered whether our participants exhibited the typical fading affect bias found in the existing literature (i.e., negative affect fades more than positive affect; Walker & Skowronski, 2009), but in the context of averaging responses on discrete emotion items (i.e., comparing positive and negative *emotions* rather than affect). We focus on four negative (disgust, fear, anger, sadness) and four positive (compassion, relaxed, hope, strong) emotions. These emotions reflect different arousal levels and are trauma-relevant: the negative emotions represent common emotional reactions to trauma (Hathaway et al., 2010) and the positive emotions indicate resilience and/or posttraumatic growth (i.e., the positive psychological change that results from adverse experiences; Tedeschi & Calhoun, 2004).

Results

The fading affect bias literature typically separates participants' reported events into positive or negative events based on their event-related affect rating (i.e., below the bipolar scale's midpoint indicates the event is unpleasant/negative, above the midpoint indicates the event is pleasant/positive; Walker & Skowronski, 2009). According to this categorization, in Study 4b, most participants rated their traumatic event as negative (M = 1.9, SD = 1.3 for Time 1 'then'; M = 3.3, SD = 1.6 for Time 1 'now'). Therefore, we had insufficient power to compare the fading affect bias between positive vs. negative events as is typically done in the fading affect bias literature (Skowronski et al., 2014). However, with regard to overall event-related affect, paired-sample t-tests revealed participants' affect toward to their traumatic event was significantly less negative from both 'then' to 'now' during Time 1 ($t(159) = -10.42$, $p < .001$, 95% CI [-1.58, -1.07], d = 1.61) and from Time 1 to Time 2 ($t(109) = -2.88$, p = .005, 95% CI [-0.83, -0.15], d = 1.80). These results suggest a pattern of trauma-related emotional improvement—rather than deterioration—among participants. Indeed, typically, participants reported a neutral affect towards their traumatic event at Time 2 (M = 3.9, SD = 1.4)

We also wondered whether our sample demonstrated the typical fading affect bias, but in relation to separate positive and negative emotion scales. As pre-registered, we averaged the four negative emotion ratings (i.e., disgust, fear, anger, sadness) and the four positive emotion ratings (i.e., compassion, relaxed, hope, strong) into mean 'negative emotion' and 'positive emotion' ratings. A two-way repeated measures ANOVA revealed a significant interaction between time (i.e., Time 1, Time 2) and event-related emotion (i.e., negative, positive), $F(1, 109) = 15.19$, $p < .001$, $\eta_p^2 = .12$. Simple contrasts showed that while negative emotion toward the traumatic event did not change in intensity over time (M = 3.0, SD = 1.4 for Time 1 'now'; M = 2.7, SD = 1.4 for Time 2 'now'; M_{diff} = 0.2; 95% CI [-0.006, 0.4], p = .057; η_p^2 = .03) positive emotions *increased* in intensity over time (M = 3.3, SD = 1.6 for Time 1 'now'; M = 4.0, SD = 1.3 for Time 2 'now'; M_{diff} = -0.5; 95% CI [-0.8, -0.3], p < .001; η_p^2 = .14). Our findings were inconsistent with the typical fading affect bias, such that negative and positive emotions did not fade over time, but rather negative emotion *persisted* and positive emotion *increased* over time. These inconsistent findings are likely because we solely measured traumatic events rather than a combination of positive and negative daily events as commonly used in the literature (Walker & Skowronski, 2009). These findings suggest participants' changes in event-related affect over time (which shifted from negative [below the scale midpoint] to neutral [nearing the scale midpoint]) is driven by increases in positive emotion over time, rather than decreases in negative emotion over time.

Discussion

Participants' trauma-related emotions did not fade over time: negative emotions persisted and positive emotions increased. Whilst these findings are not consistent with the typical fading affect bias trajectory, they are consistent with the underlying function of this bias as a mechanism for adaptive coping and emotion regulation (Skowronski et al., 2014; Walker & Skowronski, 2009). Participants' increase in intensity of trauma-related positive emotions over time is consistent with the typical trajectory of trauma processing and resiliency in the months after a traumatic event (Ehlers & Clark, 2000). Indeed, approximately 95% of trauma-exposed people will *not* develop PTSD (APA, 2022; Frans et al., 2005). Our finding that people's trauma-related negative emotions persisted over time was consistent with prior research exhibiting a disrupted fading affect bias among people with psychopathology—where negative affect fades slower than usual (Bond et al., 2022; Marsh et al., 2019). Thus, the negative emotions associated with traumatic experiencing may be particularly pervasive, which may increase a person's risk of developing and maintaining PTS symptoms if they do not additionally experience posttraumatic growth.

Chapter 7: General Discussion

In this thesis I aimed to determine whether enhanced memory for disgust (relative to fear) extends to various forms of episodic memory, including: intrusions (which I interchangeably term *involuntary memories*), memory accuracy (addressing limitations from past research), and memory for the emotions associated with an event. I focused primarily on memory contexts relevant to traumatic experiences (i.e., intrusions and persistent emotions). Given *fear* is a well-researched, memorable and trauma-relevant emotion in PTSD diagnostic criteria (APA; 2022; Levin-Aspenson et al., 2021; Pickel, 2009), I compared memories for disgust with memories for fear across all studies to understand the clinical significance of disgust's memorability. I also compared memories for disgust (and fear) with memories for neutral stimuli across the studies where I used image stimuli (Chapters 4 and 5) to examine and replicate the emotionally enhanced memory effect (e.g., Cahill & McGaugh, 1995). As an exploratory interest, I examined whether trait disgust (i.e., disgust propensity and sensitivity) or posttraumatic stress symptoms were related to memory for disgust. In this final chapter, I summarise the findings from my four empirical chapters and discuss these findings in the context of past research and theories I introduced in Chapter 1. I also outline the clinical implications of my research, the methodological limitations and implications associated with my research, and suggests future research directions.

7.1 Disgust's Memorability

The main aim of my thesis was to replicate and extend the literature showing disgust memory enhancement by comparing memory for disgust and fear across various settings and forms of memory. I examined episodic memory for disgust and fear *content* (i.e., stimuli and personal experiences) and past *emotions* (i.e., feelings of disgust). I measured various forms of episodic memory for disgust and fear, including both involuntary memory (i.e., intrusion characteristics, frequency and symptom severity) and voluntary memory (i.e., memory accuracy [including false memories and correct recognition] and memory for emotion). Overall, I found *partial* evidence for disgust memory enhancement (relative to fear). Across Chapters 3-6, people remembered disgust better than fear in some cases, while people similarly remembered disgust and fear in other cases. Although, in Chapter 3, even though people similarly remembered disgust and fear, disgust *uniquely* predicted memory (i.e., over-and-above fear). Notably, I found *minimal evidence* of fear memory enhancement (relative to disgust). One possible exception is in Chapter 5 (Study 3), where people experienced more *false* memories of fear images that were unrelated to previously encoded images, compared to unrelated disgust images. But because it was false memories for fear images that were enhanced (i.e., not correct recognition rates), these findings still fit with the idea that people have *better* (i.e., more accurate) memory for disgust than fear. Taken together, my findings suggest disgust 'sticks' in memory; below I elaborate on contexts where memory for disgust overrides memory for fear, and contexts where disgust and fear are comparably memorable.

Disgust is More Memorable Than Fear

In Studies 1 (Chapter 3) and 2 (Chapter 4) I examined *intrusions* for disgust and fear. I first discuss my results that *support* disgust memory enhancement for intrusion frequency (Study 2) and then intrusion characteristics (Studies 1 and 2). Prior research found people voluntarily recall more disgust than fear stimuli, even when those stimuli are matched on arousal, valence, distinctiveness and/or organisation (Chapman et al., 2013; Chapman, 2018; Charash & McKay, 2002; Ferré et al., 2018; Moeck et al., 2021; Schienle et al., 2021). I tested whether this bias toward disgust extends to involuntary memory. Whilst prior work shows people can experience intrusions for disgust-related stimuli (e.g., vomit, bodily harm; Arnaudova & Hagenaars, 2017; Bomyea & Amir, 2010), no research had compared how frequently people involuntarily remember (i.e., experience intrusions of) disgust and fear (or other emotional) stimuli. Understanding whether people are particularly prone to disgust intrusions (i.e., more so than is typical for other emotions) is important because intrusions are a key symptom in certain mental health disorders where a person may experience disgust (and thus, disgust-related intrusions) in addition to—or, instead of—fear (i.e., PTSD and OCD; APA, 2022; Badour & Feldner, 2018; Mitchell & Olatunji, 2024). To address this gap in the literature, I compared intrusion *frequency* of disgust and fear images in Study 2, using image sets closely matched on memory-enhancing variables (arousal, valence and distinctiveness). In Study 2a, I found that people experienced more frequent intrusions of the disgust than fear images when the image sets were matched on arousal and valence. Thus, disgust memory enhancement extended from voluntary to involuntary memory. These results support the idea that voluntary and involuntary memory share basic encoding and mechanisms where, the features of an experience that typically enhance voluntary memory—like its emotional intensity, rehearsal, vividness and recency—also enhance involuntary memory (Berntsen, 2010; Rubin & Berntsen, 2009; Schlagman & Kvavilashvili, 2008). Thus, I found some evidence for a disgust memory advantage in intrusion frequency.

My research is the first to compare disgust and fear intrusion *characteristics*, defined as features that accompany an intrusion (e.g., emotional intensity). It is common to experience recurrent intrusions (of both emotional and non-emotional experiences; Berntsen & Rubin, 2008). But people are only at risk of poor mental health outcomes—like developing Posttraumatic Stress Disorder (PTSD)—when their intrusions are persistent *and* accompanied by problematic characteristics (e.g., distress; Marks et al., 2018). I found preliminary evidence in Study 1 that disgust reactions are associated with more *negative* intrusions than fear reactions. Specifically, disgust reactions to a recent traumatic event moderately correlated with more negative intrusions (r = -.35), whereas the association was smaller for fear reactions (r = -.19). However, intrusions in Study 1 were not specific to disgust or fear (rather, in relation to people's traumatic events in general).

Expanding Study 1's preliminary evidence, Study 2b's results provide compelling evidence that disgust memory enhancement translates to intrusion characteristics. In Study 2b, people's disgust-related intrusions grew in emotional intensity over time, whereas their fear-related intrusions did not. Put differently, people's intrusions of the disgust and fear images were similarly emotionally intense to begin with, but disgust-related intrusions became more emotionally intense over a 24-hour delay whereas fear-related intrusions remained at a similarly low emotional intensity over this delay. These intrusion characteristic findings support the proposition that disgust elicits additional consolidation processes to fear, promoting disgust memory enhancement after longer delays (Moeck et al., 2021; Riegel et al., 2022). Thus, disgust memory enhancement extends to intrusions—in the context of disgust intrusions becoming more emotionally intense over time than fear intrusions.

In Study 3 (Chapter 5) I examined *memory accuracy* for disgust and fear images. We know from prior research that people correctly recognise more disgust than fear images, and falsely remember a similar—but low—proportion of disgust and fear image lures (Chapman et al., 2013; Croucher et al., 2011; Marchewka et al., 2016; Schienle et al., 2021). However, these studies had various limitations (e.g., small sample sizes and using unrelated image lures, or using related lures that were not normed on similarity/relatedness). I addressed these limitations in Study 3. I found that regardless of lure type, people remembered the disgust images more accurately than the fear images. Consistent with past research, memory accuracy was driven by higher correct recognition rates for disgust than fear, rather than false memory rates. Notably, people used a more lenient criterion (i.e., liberal response bias) for disgust than fear; they favoured identifying disgust images as 'old' (i.e., that they had previously seen the image) and fear images as 'new' (i.e., that they had not seen the image before). Perhaps people use a lenient criterion for disgust stimuli due to disgust's evaluative properties, such that disgust is easily acquired and difficult to get rid of, even when disgust-related threats are removed (Olatunji & Sawchuk, 2005). In other words, people may perceive people/objects who contact (or associate with) a disgusting person/object as ‘permanently’ disgusting. As a result, the consequences of missing a disgust threat outweigh the consequences of falsely remembering disgust. Therefore, people may err on the side of caution, favouring identifying disgust stimuli as ‘old’ when feeling uncertain about whether they had seen the stimuli before or not. Notably though, people better discriminated between previously seen/unseen disgust (than fear) images, suggesting a stronger memory trace for disgust than fear. Thus, disgust memory enhancement extends to accurate memory.

People typically remember the *emotions* felt during an experience more often than they remember the details of an experience (Levine et al., 2009). Given people remember disgust *content* (e.g., images) better than fear content, they may also persistently experience the disgust emotion itself to a greater extent than they experience fear. Specifically, when recalling a past traumatic event, people may feel similarly disgusted—and less frightened—at present relative to how disgusted (and frightened) they felt at the time of the event. To test this idea, in Studies 4a and 4b (Chapter 6) I examined how feelings of disgust and fear (in response to a recent traumatic event) fade—or, persist—in memory. Across both studies, I found that disgust persisted in memory to a greater extent than fear; whilst people’s feelings of disgust and fear faded in intensity from ‘then’ (i.e., retrospectively, when the event occurred) to ‘now’, disgust faded to a lesser extent than fear. Put differently, when a traumatic event has passed, the intensity of people’s disgust reactions is maintained to a greater extent than the intensity of their fear reactions. Thus, disgust memory enhancement extends to persistently feeling disgust.

Taken together, I found evidence that enhanced memory for disgust—relative to fear—extends to intrusion characteristics, memory accuracy and persistently remembering feelings of disgust. Disgust memory enhancement occurred in some variation across all four empirical chapters, and in relation to both personal traumatic experiences and negative experimental stimuli. But I did not always find disgust memory enhancement.

Disgust and Fear are Similarly Memorable

Disgust and fear shared similarities across intrusions, persistently feeling each emotion over time (i.e., longitudinally), and false memories. Regarding *intrusion frequency* in an experimental setting, people experienced more intrusions of disgust than fear images in Study 2a, but *not* in Study 2b when I additionally matched the disgust and fear image sets on distinctiveness. In Study 2b, people experienced a similar number of disgust and fear intrusions, both immediately after encoding and over a 24-hour delay. Therefore, it is plausible that in Study 2a, people perceived the disgust images as more distinctive—or, unusual and eye-catching—than the fear images, which may have driven disgust memory enhancement. Consistent with past research (Chapman et al., 2013)—and because distinctive stimuli are particularly memorable (Talmi, 2007a)—I controlled for distinctiveness as a potential confound in Study 2b. However, if Study 2a's disgust images were in fact more distinctive than the fear images, distinctiveness may be a mechanism—rather than a confound—for disgust memory enhancement. Put differently, these potential pre-existing differences in distinctiveness may reflect real-world differences where disgust stimuli are inherently more distinctive—and thus, memorable—than fear stimuli. Nevertheless, disgust memory enhancement did not occur for involuntary memory frequency in Study 2b. These results are consistent with West and Mulligan (2021), who did not replicate disgust memory enhancement for voluntary memory frequency across two (out of three) experiments. Thus, another potential explanation for why disgust memory enhancement did not replicate from Study 2a to 2b—as West and Mulligan argue—is that disgust's advantage in memory is replicable but less robust across different samples and experimental designs than what previous research suggests.

Turning to intrusion *characteristics*, in Study 1 I found that people's disgust reactions to a recent traumatic event correlated with intrusion characteristics and symptom severity to a comparable extent to fear. Thus, like fear, disgust reactions were associated with intrusion characteristics central to the development and maintenance of broader PTS symptoms (e.g., distress, emotional intensity; Bryant et al., 2017; Marks et al., 2018). Turning to specific intrusion characteristics, trauma-related disgust correlated with more distressing, vivid, unwanted, 'here-and-now' qualities, and emotionally intense trauma-related intrusions. The effect size of each of these correlations was similar to the equivalent effect size for the correlations between trauma-related fear and each respective intrusion characteristic (with the exception of 'here-and-now' [reliving] qualities, which was stronger for fear than disgust reactions). Thus, fear reactions appear particularly prominent during trauma flashbacks (i.e., when a person feels as though they are reliving the traumatic event itself). Unlike Study 2—where people's disgust intrusions were more emotionally intense than their fear intrusions—intensity ratings for disgust and fear positively correlated with more emotionally intense trauma memories. Indeed, in Study 1 I measured trauma-related intrusions (rather than intrusions specific to disgust vs. intrusions specific to fear). Fear's significance in trauma memories is well documented in the literature and in diagnostic tools for PTSD (APA, 2022; Izquierdo et al., 2016; Levin-Aspenson et al., 2021; Perry, 1999). Therefore, these results highlight that disgust is similarly significant to fear in trauma memories. As we know is the case for fear, when people experience disgust in response to a traumatic event, they may be at greater risk of experiencing persistent intrusions that are accompanied by 'problematic' characteristics known to activate broader posttraumatic stress symptoms (e.g., avoidance, future intrusions; Marks et al., 2018).

In Study 4, I found that trauma-related disgust and fear reactions similarly persisted over time (i.e., a three-month period). Although this longitudinal persistence was not a direct measure of memory for disgust and fear, we can wonder *why* disgust and fear may similarly persist over time. One possibility is that a bi-directional relationship exists between feelings of disgust (and fear) and intrusions of disgust (and fear). When a person continues to feel disgusted as time passes since the event, this feeling may cue the retrieval of disgust-related intrusions and vice versa (when a person experiences a disgust-related intrusion, they may then feel disgust). The same applies to fear. Notably, however, the disgust and fear reactions observed over the three-month period in Study 5 were low in intensity overall and therefore, future research should replicate these results in a population where people typically experience *intense* disgust and fear reactions (e.g., sexual assault survivors; Badour et al., 2013c).

Turning to memory *accuracy*, emotional memories are not always accurate (Berntsen, 2001; Laney & Loftus, 2008; Levine et al., 2009). Thus, in Study 3 I examined whether people falsely remember a higher, lower or similar proportion of disgust than fear images. I found similar rates of false memories for disgust and fear in Study 3, but only for *related* image lures. Because the related image lures depicted the same type of content as previously encoded ‘old’ images (whereas unrelated lures depicted completely new content), people likely felt a sense of familiarity when viewing related lures at test. In turn, they may incorrectly attribute this sense of familiarity as a memory of previously viewing the image, leading them judge this ‘new’ image as ‘old’ (i.e., experience *source monitoring errors*; Lindsay & Johnson, 2000). My findings suggest that when source monitoring confusion increases—for example, after rehearsing stimulus details (e.g., via discussion with others, mulling over the details of the stimulus/event, or remembering similar past experiences; Strange & Takarangi, 2015)—people are similarly prone to falsely remembering disgust and fear.

We know that falsely remembering certain, potentially disgust- and/or fear-eliciting, traumatic experiences (e.g., murder, rape) can lead to adverse outcomes. One catastrophic outcome here is a victim or witness of a violent crime unknowingly identifying an innocent person as the perpetrator, leading to a wrongful conviction. Wrongful convictions can occur when a victim or witness misidentifies an innocent person in a lineup who shares similar attributes to the guilty person (e.g., the same racial background; West & Meterko, 2015). My findings suggest people are not inclined to experience more (or less) source monitoring errors when they feel disgust, fear, or both emotions during a traumatic event. However, in Study 3 people did have fewer false memories of disgust than fear *unrelated* lures. Thus, perhaps people are more likely to falsely remember entirely new scenes of a fear-eliciting than disgust-eliciting event (e.g., falsely remembering seeing someone holding a weapon during a crime, yet there was no weapon at the scene). Notably though, people used a more stringent criterion (i.e., conservative response bias) for disgust *and fear* unrelated lures, such that they favoured identifying these images as ‘new’ (i.e., that they had not seen the image before). Given people falsely remembered a low proportion of unrelated lures (i.e., .10 – .22) overall, one explanation for these response bias results is that people could accurately identify (with certainty) that they had not seen the ‘new’ image lures before.

Taken together, disgust memory enhancement—relative to fear—does not always occur. Across all empirical chapters, I found evidence for both disgust memory enhancement *and* similar memorability for disgust and fear. My thesis adds to the literature on disgust’s memorability (relative to fear), which has largely concentrated on voluntary memory recall and—to a lesser extent—memory recognition.

7.2 The Relationship Between Trait Disgust and Memory for Disgust

As an exploratory interest, I examined whether trauma-related disgust (reactions and memories) correlated with higher levels of trait disgust (Studies 1 – 3). Here, trait disgust refers to *disgust propensity* (how easily, frequently and/or intensely people experience disgust) and *disgust sensitivity* (the degree to which disgust experiences are perceived as negative, unbearable and/or harmful; Olatunji & Cisler, 2009; van Overveld et al., 2006). In studies where I used disgust/fear images, I found partial evidence (Study 2a, but not Studies 2b and 3) that trauma-related and intrusion-related disgust positively correlates with trait disgust, as measured by the modified and original versions of the Disgust Propensity and Sensitivity Scale – Revised (DPPS-R; Goetz et al., 2013; van Overveld et al., 2010). Comparatively, I found no relationship between memory for disgust (i.e., frequency and/or accuracy) and trait disgust, as measured by the moral disgust subscale of the Three Domains of Disgust Scale (TDDS, Studies 1 and 2a; Tybur et al., 2009), the Disgust Scale – Revised (DS-R, Study 2a; Olatunji et al., 2007c) and the Disgust Avoidance Questionnaire (DAQ, Study 3; von Speckelsen et al., 2022). Therefore, I did not observe a robust relationship between higher levels of trait disgust and memory for disgust. However, whilst I found mixed evidence for a relationship between trait disgust and memories of disgust *images* (Studies 2 and 3), I found a consistent relationship between trait disgust, and experiencing disgust-related feelings and intrusions following a recent personal *traumatic event* (Study 1). Notably though, these exploratory analyses—except for Study 1—yielded small effect sizes and were insufficiently powered to detect stable correlations for these effect sizes (Schönbrodt & Perugini, 2013; 2018), thus limiting the conclusions I can draw from Studies 2 and 3. Therefore, I focus on findings from Study 1 in greater detail below.

In Study 1 I found higher disgust *propensity* predicted more intense traumatic event-related *and* intrusion-related disgust reactions. Consistent with prior research (Bomyea & Amir, 2010; Charash & McKay, 2002), these findings suggest people who easily experience disgust may have a low threshold for both feeling disgust and experiencing intrusive memories of disgust after traumatic events (Knowles et al., 2019). My thesis is the first research to examine whether a relationship exists between disgust *sensitivity* (i.e., perceiving disgust experiences as negative, unbearable and/or harmful) and memory for disgust. I found higher disgust sensitivity only predicted more intense traumatic event-related and intrusion-related *physical* disgust reactions; *not* disgust reactions in general (measured via a single-item, asking people how intensely they felt ‘disgust’). Here I defined physical disgust as “feeling dirty, contaminated, revolted, deformed and/or diseased”, which may reflect disgust that is more objectively harmful (i.e., posing a genuine risk for disease acquisition) in comparison to broader disgust elicitors. Thus, perhaps people who perceive disgust as negative and/or harmful are particularly prone to experiencing increased intrusions about contamination/disease-specific disgust. Notably, disgust propensity moderated the relationship between disgust sensitivity, and event- and intrusion-related disgust. Therefore, people who perceive disgust as negative/harmful may experience disgust on a more frequent basis, perhaps due to an innate tendency to attend to disgust-related information (Carretié et al., 2011). This enhanced attention towards disgust may then result in better encoding, and frequent memories, of disgust.

In Study 1 I found no relationship between people’s propensity to experience *moral disgust* (via the moral subscale of the TDDS) and traumatic event-related or intrusion-related disgust reactions (including *moral* disgust reactions). One possibility is that people’s traumatic events did not elicit moral disgust, however this explanation is unlikely because people’s trauma-related moral disgust reactions were highly correlated with their general disgust reactions ($r = .79$, $p < .001$). Thus, people who felt intense disgust in response to their traumatic event typically endorsed feeling intense moral disgust as well. Researchers have raised concerns regarding the moral subscale of the TDDS’s construct validity; this subscale may better measure anger (Olatunji et al., 2012) and broader objections to non-cooperative behaviours (Tybur, 2021), than moral disgust. Furthermore, disgust scales like the TDDS and

DS-R appear better conceptualised as measures of context-dependent *state* (rather than trait) disgust because they focus on disgust responses to specific elicitors (e.g., in the TDDS, finding the concept of "forging someone's signature on a legal document" disgusting; Consedine, 2021; Olatunji & Cisler, 2009). In contrast, the DPPS-R is best conceptualised as a measure of context-independent trait disgust ("I think feeling disgust is bad for me") and thus, more useful in examining how disgust-specific vulnerabilities contribute to psychopathology (e.g., intrusion and broader PTS symptoms; Olatunji et al., 2007a). Therefore, the DPPS-R appears a better measure of the relationship between trait disgust, and trauma-related disgust reactions and memories, relative to other disgust scales I used.

Taken together, I found partial evidence for a relationship between higher levels of trait disgust and more disgust-related intrusions, particularly for *disgust propensity* in response to personal trauma. This relationship between disgust propensity and intrusions suggests people who are particularly prone to experiencing disgust may also be prone to experiencing disgust-related intrusions, via an attention and encoding mechanism. Such intrusions may have adverse outcomes like the development of PTSD (Badour & Feldner, 2018). Indeed, we know that disgust propensity and disgust sensitivity are associated with more severe symptoms for various mental health disorders (PTSD, OCD, specific phobias and eating disorders; Ferreira et al., 2021; Olatunji & Sawchuk, 2005; Olatunji et al., 2007a; Olatunji et al., 2023; Troop & Baker, 2009). However, given inconsistent evidence overall, future research with sufficient sample sizes to detect stable correlations (Schonbrudt & Perugini, 2018) should further investigate the interplay between trait disgust and memories for disgust.

7.3 The Relationship Between Disgust and PTSD Symptoms

As another exploratory interest, I examined whether a relationship exists between trauma-related disgust and more severe PTS symptoms (Studies 1 and 4). Consistent with past research (Badour & Feldner, 2018; Badour et al., 2012; Bomyea & Allard, 2017; Coyle et al., 2014), I found people's disgust reactions to a recent traumatic event correlated with more severe PTS symptoms in relation to that event (Study 1). This correlation was large and similar in size to the correlation between trauma-related fear reactions and PTS symptoms. Thus, when people experience disgust during/following traumatic events, they may be at risk of more severe PTS symptoms (just like they are when they experience fear). Indeed, intense trauma-related disgust reactions correlated with all types of PTS symptomatology (i.e., more severe intrusions, avoidance symptoms, negative alterations in cognition and mood, and alterations in arousal and reactivity). These results are consistent with Dalgleish and Power's (2004) conceptualisation of disgust's role in the development and maintenance of PTSD: when people experience intrusions that evoke feelings of disgust and nausea, they avoid trauma reminders to avoid these intrusions and associated feelings, and are hypervigilant for signs of contamination.

Notably, in Study 1 I found that disgust reactions *uniquely* predicted PTS symptoms (i.e., over-and-above fear reactions). These results are consistent with prior research (Badour et al., 2013c) and demonstrate a clinically significant relationship between disgust and PTS more broadly (beyond re-experiencing/intrusion symptoms) that is not just due to overlap between disgust and fear (i.e., because they are both negative/arousing emotions). In Study 4 I further examined whether there is a relationship between PTS symptom severity and persistently remembering feelings of disgust (i.e., when retrospectively remembering peritraumatic disgust reactions vs. when considering current trauma-related disgust reactions). However, I found no relationship between persistently feeling disgust and PTS symptoms. Thus, disgust appears to persist in memory regardless of a person's PTS symptom severity.

I also examined the relationship between disgust-related memories (for images) and PTS symptoms (Studies 2 and 3). However, as for trait disgust, these analyses were insufficiently powered to detect stable correlations (Schönbrodt & Perugini, 2013; 2018) and thus, results should be interpreted with caution. I found mixed evidence for a relationship between more disgust intrusions and more severe PTS symptoms; this relationship was small but significant immediately after encoding in Study 2a (but *not* Study 2b), as well as over a 24-hour delay in Study 2b. Thus, perhaps the relationship between frequent intrusions of disgust and PTS symptom severity is more pronounced after a period of memory consolidation. Indeed, people's intrusions of disgust became more emotionally intense over a delay (after memory consolidation), which may worsen PTS symptoms. I found no significant relationship between fear intrusion frequency and PTS symptom severity in Study 2; this finding was unexpected given I found comparable correlations between trauma-related disgust and fear reactions, and PTS symptoms, in Study 1. Given correlations between fear intrusion frequency and PTS symptoms were small (*r*s = .06 - .16), Study 2 may have required a larger sample size to detect a statistically significant relationship between these variables. In Study 3 I found no significant relationship between disgust-related memory recognition (or, accuracy; i.e., false memories, correct recognition, memory sensitivity and response bias) and PTS symptom severity (*r*s = -.10 – .13), again perhaps because the sample size was not powered to detect these small effects. Alternatively, given memory recognition is not a key symptom of PTSD (like intrusions are; APA, 2022), perhaps no relationship exists between disgust-related memory recognition and PTS symptoms.

Taken together, disgust-related memories are *sometimes* associated with more severe PTS symptoms. This relationship may be more pronounced for *personal trauma*-related disgust than for *analogue trauma*-related disgust (i.e., disgusting images). There are two potential explanations for this more pronounced relationship: (1) people likely felt more distress in response to a personal trauma than an analogue trauma (thus, resulting in more severe PTS symptoms; Mooren et al., 2019) and (2) PTS symptoms were indexed to people's personal trauma (and not their analogue trauma), thus reflecting more of a 'true' relationship between disgust memories and PTS symptoms. Given experiencing disgust-specific intrusive memories—a key symptom of PTSD (APA, 2022)—may play a role in maintaining/worsening PTS symptoms, future research is required to establish robust conclusions about the relationship between disgust memories and PTS symptoms.

7.4 Theoretical Implications

Here I discuss three mechanisms (*attention, rehearsal* and *impact* [including *distinctiveness*]) that may drive disgust memory enhancement, and consider why people did not always remember disgust better than fear across different memory measurement types. I also discuss how my findings fit with dimensional and discrete accounts of emotion.

Attention as a Mechanism for Disgust Memory Enhancement

The prevailing explanation for disgust memory enhancement (initially discussed in Chapter 1) is that people pay more attention to disgust than fear, which leads to better memory encoding of disgust stimuli (Carretié et al., 2011; Mitchell & Olatunji, 2024). Indeed, disgust's attentional salience—relative to fear—is robustly found in prior literature (e.g., Chapman et al., 2013; Chapman, 2018; Cisler et al., 2009; Fink-Lamotte et al., 2021; Fink-Lamotte et al., 2022; Moeck et al., 2021; van Hooff, et al., 2013) and in my research (Studies 2a, 2b and 3). However, only a handful of studies had examined whether attention *explains* disgust memory enhancement (Chapman et al., 2013; Chapman, 2018; Moeck et al., 2021). Given these studies yielded inconsistent results, I examined the role of attention in the relationship between disgust and intrusion frequency in Studies 2a and 2b. I found partial evidence (in Study 2b but not 2a) that attention *moderates* the relationship between disgust and intrusion frequency. That is, the relationship between disgust and intrusion frequency is stronger when people pay more attention to the disgust images. However, consistent with Moeck et al. (2021), I found that enhanced attention towards the disgust images *did not* account for disgust intrusion frequency. Thus, spending longer attending to the disgust images increased the *likelihood* that a person would involuntarily remember those disgust images, but disgust did not influence intrusion recall *through* enhanced attention. As in Moeck et al., I used a more robust analytic approach than previous research (Chapman, 2018; Chapman et al., 2013) to examine attention's role in mediating the relationship between disgust ratings and memory frequency. Therefore, my results provide compelling evidence that—whilst people may typically remember disgust images that they paid more attention to—this enhanced attention towards disgust does not *explain* intrusion frequency of disgust images.

Why Does Enhanced Attention not Lead to Enhanced Memory for Disgust?

In Chapter 4 (Study 2), I proposed that disgust's attentional salience—yet lack of memory enhancement—may reflect *attentional rubbernecking* (Fink-Lamotte et al., 2022). Here, people pay attention to disgust stimuli but in an isolated, or 'fragmented', way (i.e., a person primarily looks at disgust-specific parts of the stimulus but not others—i.e., different bits of mould on a piece of food—and do not encode the whole stimulus in memory). In other words, according to this explanation, people are drawn to disgust stimuli but engage in cognitive avoidance by not processing the details of the stimuli in depth. However, my results from Study 3—that people paid more attention to, and more accurately remembered, disgust than fear—do not support the proposition that enhanced attention towards disgust stimuli results in attentional rubbernecking. People were better at differentiating between disgust (than fear) images they had/had not previously seen—even when unseen images depicted content related to previously seen images—suggesting people cognitively engaged with the disgust images during encoding.

Another possibility is that attention *does contribute to* disgust memory enhancement, but in a way that I did not measure. I measured attentional engagement (or, attentional capture and hold), where a person's attention is drawn to a stimulus and they have trouble disengaging their attention away from the stimulus. In my studies, people viewed the disgust and fear images whilst completing a line discrimination task (i.e., indicating the location of an adjacent line, where slower response times denote greater attentional engagement). However, increased attention toward disgust over fear occurs through two pathways: attentional engagement (e.g., Chapman, 2018; Moeck et al., 2021) *and attentional shift* (i.e., a person moves their attention from one location to another; Schienle et al., 2021). Attentional shift is measured via eye-tracking and prior research shows that people "hyper-scan" disgust stimuli (i.e., quickly shift their attention between picture details; for example, inspecting each piece of food in an effort to detect mould, discolouration, or other signs of contamination) but attend to fewer details of fear stimuli (Fink-Lamotte et al., 2022). This detailed exploration (or, hyper-scanning) of disgust stimuli likely results in deeper processing of specific stimulus details and thus, better memory encoding of disgust than fear. To determine which attention mechanism (if any) best predicts memory for disgust, future research should measure attentional engagement (measured via a line discrimination task) *and* attentional shift (measured via eye-tracking) within a single study examining memory recall for disgust.

Why do People Have an Attentional Bias Toward Disgust?

From an evolutionary standpoint, attending to—and remembering—disgust is particularly important for human survival. At its core, the revulsion and avoidance response associated with disgust functions to protect humans from threats of contamination (Darwin 1965/1872; Ekman, 1992). Whilst medical advances (e.g., vaccines) have increased our ability to withstand infection, disease acquisition remains the biggest threat to human livelihood (Bradshaw & Gassen, 2021). To contextualise, communicable diseases (i.e., infectious diseases spread via contamination, like respiratory infections) accounted for one quarter (26%) of human deaths globally in 2019 (World Health Organisation, 2019). Fear functions to protect us from predatory threats of danger (and thus, like disgust, ultimately functions to avoid mortality; Öhman, 2008). However—likely attributed to evolutionary processes, including the development of advanced societal structures—we are less exposed to predatory threats (than our earliest ancestors were) in society today. Anecdotally, most of us would know more people who have died from disease/illnesses than from a violent attack. Thus, perhaps we have become ‘hardwired’ to be alert to threats of contamination above all other threats.

Carretié et al.’s (2011) cost and benefit hypothesis posits the ambiguous, subtle and low-urgency nature of disgust threats (e.g., contamination) leads people to pay greater attention to disgust than fear stimuli. Spending longer attending to fearful stimuli is costly because these stimuli threaten immediate danger and an urgency to flee (or fight) the situation. In contrast, because disgust-related threats (e.g., mouldy food) do not pose immediate danger, there are fewer costs associated with spending a longer amount of time examining disgust stimuli. Furthermore, given disgust stimuli are subtle (e.g., difficult to observe, and at times only detected via other sensory modalities, such as smell), easily transmitted and resistant to decay (e.g., some illnesses end after days, weeks or even longer), there are greater costs associated with only superficially attending to—and as a result, omitting, misjudging and/or misremembering—disgust stimuli. In fact, greater exploration of disgust stimuli maximises potential benefits; following visual inspection, a person may deem the stimulus safe and thus, approachable/consumable. This logic fits with the idea that people orient and maintain their attention towards disgust stimuli, but also *shift* their attention to more closely inspect stimulus details (e.g., hyper-scanning). Counter to the predictions for disgust-specific attentional rubbernecking, the cost and benefit hypothesis presumes that longer—and detailed—exploration of disgust allows for better encoding and subsequent memory retrieval of disgust relative to fear. In Study 4 I found that people paid more attention to—and had more accurate memory for—disgust than fear images, supporting the cost and benefit hypothesis.

Taken together, there is a sound theoretical base for why people pay greater attention to disgust than fear. Specifically, disgust threats are noxious, ambiguous, subtle, easily transmitted, long lasting, and remind us of our mortality. Therefore, people have a strong desire to avoid contact with disgust. Prioritising attention towards disgust threats allows people to maximise the likelihood of avoiding such contact. Consistently, I found that people maintained their attention towards disgust longer than fear stimuli. Notably, this enhanced attention did not translate to enhanced memory for disgust. However, these findings do not necessarily mean that attention is inconsequential in relation to disgust's memorability. Rather, it is likely the combination of attentional engagement (i.e., time spent looking at), attentional shift (i.e., deeply processing stimulus details), and processes that occur after encoding (e.g., consolidation) that contribute to disgust's memorability.

Rehearsal as a Mechanism for Disgust Memory Enhancement

Perhaps processes after encoding—namely, *rehearsal*—are particularly relevant to disgust memory enhancement. We know that people rehearse emotional events more than neutral events, and this rehearsal occurs in three key ways: (1) *socially discussing* the event with others, (2) *voluntarily* thinking about (or, remembering) the event (i.e., for the purposes of wanting to remember, problem solving and/or making meaning of the event), and (3) *involuntarily* (i.e., spontaneously and unintentionally) thinking about (or, remembering) the event (Guy & Cahill, 1999; Walker et al., 2009). Thus, memory *recall* also functions as *memory rehearsal*. Rehearsal strengthens a memory's trace (via repetition of the memory), which enhances memory consolidation and the likelihood that a memory is retrieved again in the future (Berntsen, 1996; Parle et al., 2006). Given rehearsal and memory consolidation occur *after* encoding, the effects of rehearsal (and consolidation) on memory can only be observed after a delay (Moeck et al., 2021; Talmi, 2013).

There is some evidence that disgust elicits additional consolidation processes to fear (Chapman et al., 2013; Moeck et al., 2021; Riegel et al., 2022) and my thesis further supports this evidence base. Specifically, I found that people had more emotionally intense (Study 2b) and more accurate (Study 3) memories of disgust than fear after a delay (ranging from 24 – 72 hours). One explanation for these findings is that people rehearsed their disgust memories more than their fear memories, which enhanced memory consolidation and subsequent retrieval. Indeed, in Study 2b people had similarly emotionally intense disgust and fear memories immediately after encoding, suggesting a post-encoding mechanism—like rehearsal—drives disgust's memory effects after a delay. Furthermore, in Study 4 I found that people's feelings of disgust persisted in memory more than their feelings of fear following a recent traumatic event. Notably, increased rehearsal (via voluntarily or involuntarily thinking about the event) reduces the extent to which negative emotions fade over time (Walker et al., 2009). In other words, rehearsing an event in memory maintains the intensity of emotions associated with the event. Thus, perhaps disgust persists in memory because people constantly rehearse (or, think about) disgust-eliciting events.

Whilst people may rehearse disgust more than fear, no prior research (to my knowledge) has examined this possibility in detail. Returning to the three ways that memory rehearsal occurs (social discussion, voluntary memories and involuntary memories), I compared memory rehearsal for disgust vs. fear in one of these ways: *involuntary memory frequency* (Study 2). Here, I found mixed evidence where disgust memories were rehearsed (i.e., recalled) similarly to (Study 2b), and more than (Study 2a), fear memories. However, I did not examine differences in how people socially discussed and/or voluntarily thought about the disgust images. Therefore, from these findings alone, I cannot determine whether differences exist—across all aspects of memory rehearsal—in how often people rehearse disgust and fear. To confirm whether rehearsal is a driving mechanism for disgust memory enhancement, we must first understand whether people rehearse disgust-related memories more than fear-related memories. Future research could test this possibility by simply asking people how often they discuss, voluntarily think about, and involuntarily think about past disgust-eliciting and fear-eliciting events.

Impact as a Mechanism for Disgust Memory Enhancement

Another explanation for disgust memory enhancement—proposed by Croucher et al. (2011)—is that disgust stimuli are more *impactful* than fear stimuli. Originally derived from photojournalism to describe powerful and striking images (Hurley & McDougall, 1971), *impact* refers to the immediate reaction (e.g., 'oh my goodness', 'yuck!' or 'what the…?') a stimulus has on a person. This immediate reaction occurs *before* a person evaluates which emotion/s they are experiencing in response to the stimulus. Therefore, when asked to rate images on their immediate impact, people are instructed: "by this [impact] we mean that before you get to think about what is in the picture you may be instantly affected by it—without necessarily knowing why" (Murphy et al., 2010, p. 607). Behavioural and neuroimaging studies found enhanced attentional engagement and increased amygdala activation for high impact—relative to low impact—images, even when those images were matched on arousal and valence (Ewbank et al., 2009; Murphy et al., 2010). Given impact influences attention and amygdala activation (mechanisms that enhance memory; Carretié, 2014; Dolcos et al., 2006), impact also likely influences memory. Whilst no research has compared memory for high impact vs. low impact images, Croucher et al. found that people were more likely to remember (i.e., correctly recognise, during a memory test) disgust, fear and positive images that they had perceived as more impactful during encoding. No other image characteristics (e.g., arousal, pleasantness) significantly predicted memory recollection for disgust and fear images. Thus, people typically remembered the disgust, fear and positive images they deemed highly impactful. Given people had better memory for disgust than fear and positive images, Croucher et al. posited that disgust stimuli may be more impactful than fear (and positive) stimuli.

What Makes a Stimulus/Experience Impactful?

Croucher et al. (2011) obtained image ratings for a range of variables (i.e., arousal, pleasantness, approach-avoidance, distinctiveness, visual complexity, negative/positive body state reactions, and ideation) and examined which characteristics predicted image impact ratings. Negative body state reactions predicted impact, suggesting this immediate impact reaction involves a visceral, physiological response (e.g., nausea, startle, clenching fists). Distinctiveness also predicted impact ratings, suggesting people deem unusual, eye-catching and/or incongruent (with prior experience) images as impactful. Ideation was the final (negative) predictor of impact ratings, referring to how many thoughts and/or ideas the image evoked. Thus, impactful images were associated with fewer thoughts/ideas, perhaps because the meaning of such striking images was easier to grasp (resulting in a fast 'oh my goodness', 'yuck!' or 'what the…?' response). Taken together, an experience is impactful when it elicits a visceral physiological response and is distinctive in nature; these attributes are also prominent during emotional experiences and subsequently enhance memory (Berntsen, 2001; Staugaard & Berntsen, 2014; Talmi, 2007a).

Disgust stimuli may elicit particularly strong body state reactions and be more distinctive than fear; accordingly, disgust may be more impactful than fear (Croucher et al., 2011). Whilst all emotions involve a physiological and embodied component (e.g., nausea for disgust, startle for fear), researchers argue these bodily reactions may be particularly pronounced for disgust relative to other emotions (Rozin & Fallon, 1987; Schnall et al., 2008;

Stevenson et al., 2019; Tybur, 2021). Indeed, Darwin's (1965/1872) definition of disgust identifies the visceral nature of the emotion, explicitly identifying four of the five sensory modalities—taste, smell, touch and eyesight—that elicit disgust. People can also detect disgust-related threats via sound (e.g., hearing coughs, sneezes and a person vomiting; Tybur, 2021). Whilst people also detect fear-related threats via some sensory modalities (e.g., *hearing* a loud bang, *seeing* a shadowy figure, *smelling* a fire), this variation may be less pronounced than it is for disgust (Davey, 2021).

Impactful stimuli are also distinctive (i.e., unusual/eye-catching; Croucher et al., 2011). I found enhanced intrusion frequency for disgust relative to fear images in Study 2a, the only study where I did not norm my image set on distinctiveness. Thus, perhaps the disgust images in Study 2a were more distinctive—thus, memorable—than the fear images. Indeed, the most frequently recalled image in Study 2a was a disgust image of a person lying in a hospital bed with bloody feet, sliced completely around their ankles). Whilst I did not obtain the relevant ratings, we can assume people perceived this kind of injury (i.e., feet sliced through, as if by a piece of wire) as unusual and novel. In contrast, people may be more familiar with the content depicted in fear images (e.g., a bushfire, a growling dog and a man pointing a gun). Furthermore, the blood and gore depicted in the disgust image likely elicited a visceral revulsion/nausea response. When I matched the disgust and fear image sets on distinctiveness in Study 2b, disgust memory enhancement did not occur; disgust and fear were similarly memorable. Taken together, disgust may be remembered better than fear due to being more *impactful*; future research should directly test this possibility (e.g., by examining whether disgust stimuli are more impactful than fear stimuli, and whether impact mediates the relationship between disgust and memory frequency).

Why was Disgust not Always Remembered Better Than Fear?

When measuring personal trauma, I found people's trauma-related disgust and fear reactions similarly persisted longitudinally (i.e., over 3-months; Study 4b) and correlated with intrusion symptoms to a comparable extent (Study 1). However, I had minimal experimental control in these studies and therefore, could not separate disgust-related events from fear-related events. One explanation for these results, then, is that disgust and fear commonly *co-occur* in response to traumatic events, leading to similar memory effects. Indeed, we know people with various mental health disorders (i.e., animal phobias, blood-injection injury phobias and contamination-related OCD) can experience a combination of disgust and fear in response to triggers (Melli et al., 2015; Olatunji & Sawchuk, 2005). Therefore, the same may be true for traumatic experiences.

There are two ways that disgust and fear may co-occur. First, given the similarities disgust and fear share—for example, both emotions are arousing, negative, and learned via similar mechanisms (e.g., classical conditioning)—experiencing one emotion may easily elicit the other emotion. To examine whether disgust also elicits fear (and vice versa), Muris et al. (2009) presented European children with pictures of unknown animals (Australian marsupials) accompanied by a story highlighting either disgust-related information (e.g., the animal is very dirty) or fear-related information (e.g., the animal is very dangerous). They found a bidirectional relationship between children's feelings of disgust and fear: receiving disgust-related information about the animal led to more intense feelings of disgust *and* fear, as did receiving fear-related information about the animal. Second, people may feel disgust and fear simultaneously, but in response to different aspects of an experience. For example, a sexual assault survivor may feel frightened towards their perpetrator (who inflicted harm) and feel disgusted toward their own body (due to evaluating themselves as contaminated).

The idea of disgust and fear co-occurring is consistent with Marzillier and Davey's (2004) distinction between simple (or, primary) disgust (i.e., core disgust) from complex disgust (i.e., all other disgust elicitors: animal-reminder, blood-injury, sexual, interpersonal, moral). While simple disgust reflects a singular emotional response (disgust), complex disgust involves varying degrees of interaction between emotions (e.g., moral disgust can also elicit anger, interpersonal disgust can also elicit pity/sadness, disgust towards animals can also elicit fear; Stevenson et al., 2019). Thus, people may experience co-occurring disgust and fear in response to certain traumatic events, but not others. Future research should examine which traumatic event categories are particularly prone to co-occurring disgust and fear.

If disgust and fear co-occur in response to a traumatic experience, what does this mean for memory for that experience? One possibility is that disgust- and fear-eliciting features of a traumatic experience are particularly memorable and, here, experiencing concurrent emotions may have a compounding effect on memory. Put differently, a traumatic event may be more memorable—in terms of more frequent and accurate memories, and stronger accompanying memory characteristics—if it elicits several emotions rather than a single emotion. Future research could test this idea by comparing memory for stimuli (e.g., images) that elicit only disgust or only fear, with memory for stimuli that elicit high levels of disgust *and* fear. Alternatively, one disgust-related or fear-related aspect of an event may be more memorable than another aspect. But when emotions co-occur, it is difficult to determine which emotion is causally responsible for memory enhancing effects. Notably, whilst I could not separate disgust- and fear-eliciting events when measuring *personal* traumatic events in Studies 1 and 4, I found (in Study 1) a relationship between disgust and intrusion symptoms, over-and-above fear. Even if disgust and fear often co-occur, disgust has unique effects on memory. Therefore, experimentally separating disgust from fear may help us to understand what some of these unique effects are.

In Studies 2 and 3 I experimentally controlled for co-occurring disgust and fear by norming and selecting images that elicited either high disgust/low fear, or high fear/low disgust. I deliberately excluded images that elicited high levels of both (i.e., co-occurring) disgust and fear. When I separated disgust from fear, I found disgust memory enhancement in some contexts (i.e., disgust memories were more accurate and emotionally intense than fear memories). However, people experienced similarly frequent intrusions of disgust and fear (Study 2b). Study 2b's findings were inconsistent with prior research on *voluntary* memory frequency (e.g., Chapman et al., 2013; Moeck et al., 2021). Thus, perhaps this lack of difference between disgust and fear memory recall was driven by differences between the disgust and fear stimuli that we did not control for (i.e., organisation). Indeed, in Study 2b, people perceived the fear image set as *more* interrelated than the disgust image set. Thus, due to conceptual similarities within the fear image sets (e.g., an image of a knife and an image of a gun both represent weapons), remembering one image may cue retrieval of the other image. We know that regardless of emotion, organisation leads to better memory *recall* (Talmi et al., 2007a) and thus, the disgust memory enhancement effect for this measurement type (involuntary recall) may have been dampened by this confound. Future research should examine this possibility by testing memory for disgust and fear images normed on organisation. Alternatively, it may be the case that disgust memory enhancement (relative to fear) is more nuanced and only occurs for some aspects of memory rather than all aspects of memory. I unpack this idea further below, where I discuss why I think *both* dimensional and discrete accounts of emotions provide insight into how emotions are remembered.

Implications for Emotion Theories

Emotion researchers often contrast two key conceptualisations of emotion—dimensional and discrete perspectives—against one another to understand the interplay between emotions and various factors, including human physiology, cognition and behaviour (Chapman et al., 2013; Harmon-Jones et al., 2017; Lench et al., 2011). Discrete and dimensional theorists define emotions differently. Broadly, dimensional emotion theorists argue emotions represent unique combinations of valence and arousal levels (e.g., Russell, 1980) whereas discrete emotion theorists argue discrete emotions (e.g., fear, disgust) manifest in qualitatively different ways (i.e., regarding physiological responses, behaviours, judgements and cognitions; e.g., Ekman, 1992). In Studies 2 and 3, I compared the dimensional and discrete accounts of emotion by examining memory for neutral images and images that belong to different emotion categories (i.e., disgust and fear; but are equated on valence and arousal). Overall, I found some support for both discrete and dimensional accounts of emotion.

Dimensional Accounts of Emotion

Dimensional accounts of emotion predict that the more arousing and pleasant/unpleasant a stimulus is, the better it is remembered. In line with dimensional accounts of emotion, I found enhanced memory for emotional images relative to neutral (i.e., non-arousing, moderately pleasant) images across all experimental studies; all with large effect sizes. These results are consistent with the well-established emotionally enhanced memory literature (that primarily measures emotion through valence and arousal; Cahill & McGaugh, 1995; Reisberg, 2006). Thus, as suggested in Chapter 1, arousal and valence may be a *necessary* part of understanding the impact of emotion on memory. But are valence and arousal differences—i.e., dimensional accounts of emotion—*sufficient*? Answering yes to this question would rely on people showing no differences in memory for stimuli (i.e., disgust and fear images) when these stimuli are matched on arousal and valence.

I found some—but minimal—support for dimensional accounts of emotion when comparing memory for (disgust and fear) stimuli matched on valence and arousal; people involuntarily recalled (Study 2b) and falsely remembered (Study 3) a similar rate of disgust and fear images. However, as discussed above, Study 2b's intrusion frequency results may not truly reflect memory for disgust vs. fear (due to the confound of organisation; Talmi et al., 2007a). I also found evidence for enhanced memory for disgust relative to fear, which does *not* support dimensional accounts of emotion. Notably, despite my efforts to equate the disgust and fear image set on arousal and valence, the images often differed—only slightly [M_{diff} = 0.2–0.6 on a 1 – 7 scale], but still significantly: people rated fear images as more arousing and disgust images as more unpleasant. This pattern fits with Figure 2 (Chapter 1), which displays where disgust and fear naturally lie on the valence/arousal continuum quadrants (Widen & Russell, 2008). Specifically, fear is more arousing than disgust, while disgust is more unpleasant than fear. Arousal has a stronger memory enhancing effect than valence (Hamann, 2001; Mather & Sutherland, 2009; Talmi et al., 2007b). Consequently, if dimensional accounts were sufficient, we should see better memory for *fear* than disgust—I found no evidence of fear memory enhancement in these studies. Thus, discrete accounts of emotion are also necessary to account for the effects of emotion on memory.

Discrete Accounts of Emotion

Discrete accounts of emotion predict that discrete emotions manifest in different ways, such that each emotion has a unique evolutionary function, and pattern of physiological, cognitive, and behavioural responses (Chapman et al., 2013; Harmon-Jones et al., 2017; Lench et al., 2011). Regarding memory, appraisal theorists in favour of the discrete account of emotion predict that people focus on, and subsequently remember, different aspects of a situation depending on which emotion they predominantly experience (Levine & Edelstein, 2009). For example, people feel *fear* when a goal has been threatened and thus, should display enhanced memory for threat-relevant information (Levine & Pizarro, 2004). In comparison, people feel disgust in response to an "unwanted association of person, object or idea that is repulsive to the self, and/or to valued roles, goals or ideals" (Dalgleish & Power, 2004, p. 1074). Accordingly, people who feel disgust should display enhanced memory for repulsion-related information. Thus, theories of discrete emotions propose people remember different details of a stimulus/experience depending on which emotion they predominantly feel. However, these theories do not predict whether events are more memorable when a person experiences *several* co-occurring emotions (vs. one emotion). Nor do they predict which stimulus details may prevail in memory in situations where a person experiences more than one emotion. Put differently, discrete accounts of emotion do not assert that certain emotions are more memorable than others. However, researchers in favour of the discrete emotions account do raise this possibility and highlight the need for research examining memory differences *between* emotions (and the underlying mechanisms for such differences; Ortony, 2021; Levine and Pizarro, 2004; Kaplan et al., 2016). My thesis helps address this need.

I found support for discrete accounts of emotion when comparing memory for disgust and fear; people experienced more accurate (Study 3), emotionally intense (Study 2b) and persistent (Study 4) memories of disgust than fear. I also found some evidence that people experience more frequent intrusions for disgust than fear (Study 2a), however, these results may have been influenced by the differences in distinctiveness between image sets (Talmi et al., 2007a). Together, these findings support the growing evidence base that people remember disgust differently to fear (and other emotions like anger and happiness; e.g., Chapman et al., 2018; Marchewka et al., 2016; Schienle et al., 2021; Wang & Ren, 2020). Although I did not always observe disgust memory enhancement, occasional null results do not necessarily disconfirm discrete accounts of emotion. Indeed, these accounts predict qualitative differences in how emotions are remembered, not consistent differences across *all* types of remembering. Perhaps the qualitative differences between memory for disgust and fear are more nuanced; these memory differences only occur in certain contexts (i.e., disgust may be enhanced in some forms of remembering but not others). Perhaps different memory measurement types (e.g., recall, recognition) and disgust stimuli (e.g., images, experiential tasks) and/or elicitors (e.g., gore, sociomoral) underlie why disgust is enhanced in memory in certain contexts but not others. Supporting the role of disgust elicitors, Arnaudova and Hagenaars (2017) found people experienced more intrusions of a disgust film displaying vomit relative to three other films that likely had disgust-elements too (i.e., physical assault, sexual violence and the scene of a fatal car accident). Here, people remembered 'core' disgust elicitors (i.e., those that provoke a threat of oral consumption of pathogens; Rozin et al., 2009) more than other disgust elicitors (e.g., animal-reminder, blood-injury and/or moral disgust; all of which the remaining films may have elicited). Continued future research is required to understand such nuances in memory for disgust (e.g., which disgust elicitors are remembered better than others, and whether only certain elicitors are remembered better than fear).

Both Accounts of Emotion are Useful in Understanding Memory for Emotions

Like some researchers in the field, I believe dimensional and discrete accounts of emotion can—and should—co-exist (Harmon-Jones et al., 2017; Barrett, 1998). Valence and arousal are unequivocally fundamental to understanding emotions (and the subsequent enhanced memory of these emotional experiences; Cahill & McGaugh, 1995; Faith & Thayer, 2001; Kensinger, 2004; Mather & Sutherland, 2009; Russell, 1980). Thus, dimensional accounts may be sufficient in understanding memory for emotional vs. non-emotional events. Indeed, I consistently found memory differences between disgust/fear and neutral stimuli were more pronounced than memory differences between disgust and fear stimuli (Studies 2 and 3). However, people also remember disgust and fear differently, which dimensional accounts alone cannot explain. Considering the discrete characteristics of these emotions may provide further insight into the complexity of how they are remembered.

The memory effects between different emotions—particularly those that share similar dimensionality—may be small and nuanced, thus requiring further consideration of their discrete manifestations. Consistently, a meta-analysis examining whether discrete emotions uniquely predict various outcome variables (i.e., cognition, judgment, behaviour, physiology) found—supporting the discrete emotions perspective—that all emotion comparisons uniquely and significantly predicted outcome variables (Lench et al., 2011). However, comparisons between emotions with different dimensionality (i.e., happiness [pleasant, high arousal] vs. sadness [unpleasant, low arousal]) were moderate-large whereas comparisons between emotions with similar dimensionality (i.e., anger vs. anxiety [unpleasant, high arousal]) were small. Thus, whilst valence and arousal may explain most of the variance in defining an emotional experience, a portion of this variance remains unaccounted for (Faith & Thayer, 2001). Here is where discrete characteristics of emotions—including their associated evolutionary function, physiological responses and distinctiveness (Ekman & Cordaro, 2011)—may provide further insight into the complexity of emotional experiences. Notably though, whilst discrete emotions may possess typical characteristics (e.g., disgust *usually* results in heart rate deceleration; Gilchrist et al., 2016), these characteristics are not always present (e.g., disgust sometimes results in no change or an accelerated heart rate; Ottaviani et al., 2013). Researchers who hold a *psychological constructionist* view toward emotion—which integrates dimensional and discrete accounts (Lindquist et al., 2013)—do not emphasise specific patterns (i.e., characteristics) in how each discrete emotion manifests

(Barrett, 2013). Rather, they view arousal and valence as necessary elements of emotion, but emphasise that people implement an additional process of (non-specific) meaning-making to make psychological sense of the change in their emotional state before identifying which discrete emotion they are experiencing (Lindquist et al., 2013).

Taken together, I found support for both dimensional and discrete accounts of emotion. Dimensional accounts of emotion may be sufficient when comparing memory for emotional (e.g., disgust) and neutral events. However, discrete accounts of emotion are better suited to comparing memory for events that elicit different emotions of similar valence (e.g., disgust vs. fear).

7.5 Clinical Implications

My thesis has clinical implications for understanding disgust's role in trauma and PTSD. First, consistent with a growing body of research (e.g., Badour & Feldner, 2018; Badour et al., 2013c; Jones et al., 2020; Dalgleish & Power, 2004), Study 1 demonstrates that disgust reactions occur during and following traumatic events, and uniquely predict PTS symptoms. The following description (taken from a participant in Study 1) highlights disgust's relevance in certain traumatic events: *On my way to work one evening, I came up to the scene of a vehicular accident…the driver had been decapitated, and his head was between the driver's seat and the passenger's seat of the car. I very nearly vomited but managed to keep control of my own vehicle and continue driving. I was very nauseated by the thought of what I had seen coming back to mind*.

Unsurprisingly, disgust reactions are common when a traumatic event comprises disgust-eliciting properties, including *physical disgust* (i.e., blood, gore, bodily fluids, e.g., the motor vehicle accident described above) and *moral disgust* (i.e., sociomoral violations, e.g., feeling abandoned by a loved one). People who work in occupations where they are often exposed to the aftermath of traumatic experiences—where the imminent threat of danger and thus, *fear*, has passed—may also experience disgust (perhaps even as their primary emotional response; Bryant, 2019; Hathaway et al., 2010). For example, emergency service responders who attend scenes of fatal motor vehicle accidents or online content moderators who are repeatedly exposed to gruesome scenes (e.g., images, videos; Pinchevski, 2023; Spence et al., 2024). Study 1's findings suggest that when people do experience these trauma-related disgust reactions, such reactions may be similarly pathological in predicting PTS symptoms to fear reactions.

Second, my thesis provides a novel contribution to the disgust and trauma field by demonstrating that disgust is comparably—if not more—memorable to fear in the context of intrusions (i.e., frequency and characteristics) and persistently remembering feelings of disgust. These forms of remembering are reflected in diagnostic criteria for PTSD (APA, 2022). Furthermore, trauma-related disgust reactions uniquely predict intrusion symptoms, including characteristics implicated in the development and maintenance of PTSD (e.g., distress and emotional intensity; Marks et al., 2018). These findings are clinically important because intrusions are central to activating and maintaining broader PTSD symptoms (e.g., future persistent intrusions, avoiding trauma-related thoughts, increased arousal/physiological reactions and feeling upset by trauma reminders (Bryant et al., 2017). Disgust's memorability in intrusions and association with worsening PTS symptoms fits with Dalgleish and Power's (2004) adaptation of Ehlers and Clark's (2000) cognitive model of PTSD, which highlights how disgust may be implicated in development and maintenance of intrusions and broader symptoms (e.g., avoidance) in PTSD. Therefore, consistent with recommendations made by researchers in the field (Badour & Feldner, 2018; Jones et al., 2020), findings from my thesis suggest disgust should be recognised as a relevant emotion in diagnostic manuals of PTSD (which, at present, recognise feelings of fear, horror, anger, guilt and shame; APA, 2022). Furthermore, when people seek psychological treatment for PTSD—and their presentation includes persistent feelings of disgust—this disgust response should be specifically targeted in treatment (Mason & Richardson, 2012).

Third, disgust's 'stickiness' in memory may explain why disgust reactions are difficult to reduce in PTSD treatments (namely, *exposure therapy*). Exposure therapy aims to reverse classical and operant conditioning processes. Specifically, repeated, gradual exposure to trauma-related cues aims to reduce avoidance behaviours and emotional distress associated with these cues (Bryant, 2019). However, research suggests that, among people with various clinical disorders (i.e., PTSD, contamination-related OCD and specific phobias), disgust reactions habituate—i.e., fade in emotional intensity—at a slower rate than fear reactions in response to exposure therapy (Harned et al., 2015; McKay, 2006; Mitchell et al., 2024; Olatunji et al., 2007b; Olatunji et al., 2009; Rouel et al., 2018; Smits et al., 2002; Zeng et al., 2021). Similarly, my Study 4 findings demonstrate that disgust fades slower—or persists longer—in memory than fear following trauma. Given disgust and fear appear to naturally fade at different rates (fear fades faster than disgust), perhaps people simply require more exposure sessions—and more time—to meaningfully and adequately decrease their trauma-related disgust reactions (Mason & Richardson, 2012). However, additional exposure sessions may not be feasible for everyone due to factors like financial or time constraints. Thus, augmenting exposure therapy with additional treatment approaches may optimally target trauma-related disgust in PTSD.

There is limited research on efficacious interventions for treating disgust in PTSD. However, treatment approaches that target disgust-related emotional dysregulation by improving a person's emotion regulation skills (e.g., identifying, understanding and accepting disgust when it occurs and implementing strategies to reduce the intensity of disgust; Varkovitzky et al., 2018) may be beneficial. Indeed, cognitive and behavioural therapies that seek to change—or support a person's ability to cope with—disgust's evaluative meaning have yielded positive outcomes (i.e., a reduction in symptomatology) when treating other disgust-related disorders (i.e., contamination-related OCD, specific phobias and eating disorders; Böhnlein et al., 2020; Fink-Lamotte et al., 2018; Plasencia et al., 2019). We know that when disgust is formed via evaluative conditioning, it is difficult to modify feelings of disgust (even when contamination threats are removed; Woody & Teachman, 2000). For example, if a cockroach has been thoroughly sanitised, people would still feel disgusted at the cockroach floating in their drink (Rozin et al., 1986). Thus, exposure therapy alone may not yield clinically significant outcomes for people with disgust-based PTSD (Badour & Feldner, 2018; Olatunji et al., 2007b). Furthermore, cognitive restructuring techniques that challenge beliefs about whether a stimulus is disgusting may not successfully treat disgust (Woody & Teachman, 2000).

Treatment approaches that pair cognitive restructuring—focused on challenging beliefs about a person's ability to tolerate the unpleasantness of disgust, *emphasising disgust acceptance*—with exposure therapy have proven successful among people with contamination-related OCD (Salmani et al., 2022). Furthermore, psychoeducation about the adaptive functions of, and common cognitive distortions (e.g., the 'once in contact, always in contact' law of contagion; Frazer, 1890/1959) associated with, disgust—and subsequently challenging the 'evidence' for such distortions—may also normalise a person's experience and improve treatment outcomes (Mason et al., 2022; Salmani et al., 2022). This approach has proven successful in reducing feelings of contamination among people with PTSD due to childhood sexual abuse (i.e., the client fixates on how many times their 'contaminated' skin cells have regenerated since their traumatic event occurred; Jung & Steil, 2013). Whilst these treatment strategies are promising, they have mostly been researched in other clinical populations (e.g., OCD) and need to be examined among people with disgust-related PTSD before conclusions can be made about their efficacy.

Overall, disgust has historically been ignored as a PTSD-relevant emotion in the academic literature, clinical practice, and public psychoeducation (Jones et al., 2020). However, consistent with a growing body of research (e.g., Badour & Feldner, 2018; Jones et al., 2020; Dalgleish & Power, 2004), my thesis demonstrates disgust's relevance in PTSD. Specifically, disgust is 'sticky' in memory, occurs in response to traumatic events, and uniquely predicts intrusion and broader PTSD symptoms. Concerningly, disgust appears resistant to common PTSD treatments; perhaps in part due to disgust's memorability (and thus, resistance to habituation), but also in part due disgust's lack of recognition as a trauma-relevant emotion in cognitive models, diagnostic criteria and treatment protocols of PTSD.

7.6 Methodological Limitations, Implications and Future Directions

My thesis studies have methodological limitations that lay the groundwork for future research on disgust (and other emotions) and memory.

Experimental Control vs. Ecological Validity

In Studies 2 and 3, I examined memory for disgust (and fear) using images, intending to maximise experimental control. However, despite extensive piloting, the disgust and fear image sets were not always equivalent on memory-enhancing variables (arousal and valence). As I discussed in the theoretical implications section, disgust images were slightly more negative (less pleasant, more unpleasant) than fear images (Studies 2 and 3), and fear images were slightly more arousing than disgust images (Study 3). Furthermore, I observed between-sample and within-sample inconsistencies in how arousing and unpleasant people perceived the disgust and fear images. For example, in Study 2a I used Chapman's (2018) disgust and fear image set (equated on arousal and valence by American undergraduates), yet my sample (Australian undergraduates) rated the disgust images as more unpleasant than the fear images. Then, in preparation for Study 2b I normed my own disgust and fear image set (equated on arousal and valence by Australian undergraduates), but the subsequent sample of Australian undergraduates who participated in the main study rated disgust images as more unpleasant, and less pleasant, than fear images. These differences in image ratings suggest there is substantial variation in how people perceive emotional content. Thus, fully equating disgust and fear images on arousal and valence proves to be a difficult task. In turn, it is difficult to directly test the memory effects of dimensional vs. discrete accounts of emotion; because dimensional accounts suggest arousal and valence drive memory effects, these variables need to be equated to compare the two accounts of emotion. Notably though, the arousal and valence differences I observed likely reflect real-world dimensional differences between disgust and fear (Faith & Thayer, 2001).

Relatedly, people were more disgusted by the disgust images than they were frightened by the fear images. In other words, the disgust images consistently elicited disgust (M_{range} = 4.8–5.1) to a greater extent than the fear images elicited fear (M_{range} = 3.9–4.6, on a 1 – 7 scale; Studies 2a, 2b and 3). Thus, perhaps people experienced more emotionally intense intrusions of disgust than fear because they perceived the disgust images as more emotionally intense than the fear images. Indeed, disgust is relatively easy to elicit via images because people feel disgust regardless of whether there is a true risk of contamination (i.e., looking at disgusting objects just makes people feel *bad*; Rozin et al., 2009). In contrast, fear is harder to elicit through images because fear occurs when a person perceives a situation as imminently dangerous (Carretié et al., 2011). Viewing images that encompass fear-inducing situations (e.g., a person pointing a gun) does not pose any real threat to the viewer, resulting in a much milder fear response than the real-life alternative (i.e., if a gun was actually pointed at a person). Nevertheless, using images offers a high degree of experimental control and thus, is an important first step in examining memory differences between disgust and fear (Consedine, 2021). Furthermore, understanding how people remember disgust (and fear) images is generalisable to certain situations (e.g., online content moderators who are exposed to gruesome images) and thus, important. Nevertheless, experimental control often comes at the cost of ecological validity.

To increase ecological validity, I examined personal traumatic events (Studies 1 and 4). Here, I examined naturally occurring patterns in how people differentially (or, similarly) feel, and subsequently remember, disgust and fear. Whilst this methodological approach provides rich insight into the functions of these emotions in the real world, it is not without its own limitations (i.e., low internal validity). For example, each person reported their own traumatic event; thus, these events varied in many ways, including content (e.g., motor vehicle accident vs. sexual assault) and severity (e.g., a person who fractures their wrist vs. a person who is permanently disabled). Furthermore, given this lack of experimental control—and the correlational nature of these studies—I could not differentiate whether feelings of disgust or fear caused worse intrusion symptoms.

Future research should employ various methodological designs to gain a more holistic understanding of the nuanced ways that people remember disgust (relative to fear). I measured memory for disgust (and fear) using images and personal traumatic events, which lie on either end of the internal validity/ecological validity spectrum. It may be fruitful to examine memory differences between disgust and fear using methodological approaches that lie somewhere in the middle of this spectrum. For example, stimuli like *films* (e.g., Gross & Levenson, 1995), *scripts* (e.g., Comtesse & Stemmler, 2017), and *virtual reality* (Inozu et al., 2020) allow for some degree of experimental control but are more 'immersive' than images, and may therefore elicit similarly intense fear as disgust responses.

Measuring Intrusions

I measured intrusions (or, involuntary memories) in Studies 1 and 2; these memories are inherently difficult to measure (Mace, 2006; Schlagman & Kvavilashvili, 2008). Intrusions occur spontaneously (i.e., without any deliberate attempt of retrieval) but I had to provide my participants with information and instructions about intrusions (e.g., in Study 2, I asked participants to record any memories of the images that spontaneously came to mind). Such instructions may have produced a demand effect (i.e., people intentionally brought memories to mind to appease the experimenter) and/or primed participants to experience more intrusions of the images than what they naturally would have (i.e., being told that they may experience intrusions increases the likelihood of intrusions occurring; Mace, 2006). Notably though, to ensure people's memories were *voluntary* (rather than *involuntary*), I asked people to rate their intrusions on *retrieval intent* and *retrieval ease*. In Studies 1 and 2, participants typically reported unintentional and easily retrieved (i.e., involuntary) memories. When I removed difficult and deliberately retrieved memories (i.e., below/above the scale midpoint on the above measures, indicating difficult and intentional—voluntary—retrieval) from my analyses in Studies 2a and 2b, the main pattern of results (regarding intrusion frequency for disgust vs. fear) did not change. Furthermore, I mitigated intrusion-related demand effects by giving people the option to respond that they had *not* experienced trauma-related intrusions in Study 1, and measuring intrusions naturalistically (i.e., with a thought monitoring diary) in Study 2b. Thus, people's memories appeared mostly involuntary (rather than voluntary).

Measuring Emotions

I measured disgust and fear using single-item scales, consistent with past research (e.g., Badour et al., 2013c; Chapman et al., 2013; Hathaway et al., 2010; Moeck et al., 2021). However, people may simultaneously experience more than one emotion and furthermore, cannot always accurately pinpoint which emotion/s they are feeling. For example, people have varying levels of emotion differentiation; some people are good at distinguishing which discrete emotion they are primarily experiencing, whereas other people are not (and rather, tend to label their emotional response as feeling *bad* and/or as feeling several discrete emotions that share similar dimensionality [e.g., disgust, fear, anger] at once; Barrett, 1998; Barrett et al., 2001; Kalokerinos et al., 2019). One solution for those who struggle to distinguish between emotional states is to measure several specific elements of the disgust and fear response. For example, Bomyea and Allard's (2017) 17-item Trauma-related Emotions Questionnaire measures different ways disgust and fear are subjectively experienced (e.g., feeling repulsed and nauseous for disgust; shaking and feeling terrified for fear). This measure also taps into the visceral nature of disgust and fear, which may further inform differences in how intensely each emotional response is experienced. Future research should compare memory for disgust and fear, using more detailed questionnaires like this scale.

I relied on self-report measures in this thesis. Although non-self-report measures of emotion exist (e.g., physiological responses, facial expressions, neuroimaging), recent studies suggest discrete emotions may not always uniquely and/or universally elicit the same physiology, facial expression and/or brain activation (Adolphs et al., 2019; Barrett et al., 2019; Bovin & Marx, 2010). Thus, a limitation of emotion research in general is that emotions are difficult to empirically study; not only are emotions subjective, but debate remains about how they should be defined and therefore, measured (Ortony, 2021). Nevertheless, understanding people's self-reported emotional experience is important; how we perceive our emotional state influences our overall wellbeing and everyday functioning (Nahleen et al., 2019).

Measuring Traumatic Events in a non-Clinical Population

Another limitation of my thesis is that I measured a broad range of traumatic events. As I discuss in the clinical implications section, it may be that only certain types of traumatic events elicit disgust (whereas a broader range elicit fear). Indeed, I found overall low intensity of trauma-related disgust in Studies 1 and 4 (M_{range} = 2.1–2.7, on a 1 – 7 scale), which were also lower than intensity of fear (M_{range} = 2.5–4.5). Therefore, disgust's memory effects may have been dampened by the fact that many people did not experience intense trauma-related disgust. Nevertheless, my thesis provides broad, and novel, insight into memory for disgust following trauma. Notably, in Study 4a I replicated my main findings—that disgust persists in memory more than fear—when examining only a subset of participants who experienced moderately intense disgust (i.e., disgust levels that were on par with fear). Thus, my results may generalise to traumatic events that elicit intense disgust reactions. To confirm this possibility, future research should examine memory for disgust in response to traumatic events known to typically elicit high levels of disgust (i.e., sexual and/or physical assault; Badour & Feldner, 2018; Badour et al., 2013a; 2013c; Coyle et al., 2014).

I found some evidence that more severe PTS symptoms are related to more intense trauma-related disgust (Study 1) and more disgust memories (Study 2). But I used a non-clinical population in my thesis studies. It is plausible that my findings extend from a non-clinical population to a PTSD population. Alternatively, given *fear* is emphasised as a key emotion in PTSD (APA, 2022), perhaps people with PTSD show enhanced memory for fear, relative to disgust. Future research should test this possibility by comparing memory for disgust and fear among people with vs. without a diagnosis of PTSD.

Limits to Generalisability

An overarching limitation of my thesis is that I only examined disgust's memorability using samples from Western, educated, industrialised, rich and democratic (WEIRD) nations (i.e., Australian university undergraduate students and American residents; Henrich et al., 2010). This limitation is notable because in Chapter 1, I highlight the cross-cultural (and within-cultural) differences regarding what people deem disgusting (e.g., Western cultures find many non-predatory animals disgusting whereas other cultures do not; Elwood &

Olatunji, 2009). No research to my knowledge has examined whether cross-cultural differences exist between how (frequently, accurately, vividly and/or persistently) people *remember* disgust. My thesis findings regarding disgust's memorability—particularly Studies 2 and 3 where image stimuli (depicting disgust elicitors) were normed by a WEIRD sample—and thus may not generalise to non-WEIRD populations. Indeed, prior research suggests cross-cultural differences exist in trait disgust; people from Ghana have higher levels of contamination sensitivity than people from the United States (Skolnick & Dzokoto, 2013). Given people high in trait disgust may be more susceptible to remembering disgust (e.g., Studies 1 and 2a; Bomyea & Amir, 2010), cultural differences might exist in memory for disgust. Future research should compare cross-cultural differences between memory for disgust in addition to examining whether disgust memory enhancement occurs in these non-WEIRD populations.

Not Explicitly Measuring Moral Disgust

One final limitation of my thesis is that I primarily focused on *physical disgust*. In Studies 1 and 4, people's traumatic events may have contained elements of moral disgust. However, I did not experimentally examine moral disgust in Studies 2 and 3. Rather, the images I used incorporated physically disgusting content (e.g., blood, body products and non-threatening animals). Of course, some of these images may have also evoked a degree of moral disgust. However, moral disgust is difficult to examine using images; moral disgust is reliant on contextual factors and typically directed towards people rather than objects (Giner-Sorolla, 2021). For example, only feeling moral disgust towards a person when you discover they are a convicted sex offender. Nevertheless, examining whether memory differences exist between physical and moral disgust is an important avenue for future research. One approach is to add context to ambiguous images by using physical disgust-related, moral disgust-related and fear-related captions, and examine any memory differences (Bridgland et al., 2019). Another approach is to compare memory for these emotions using narrative scripts (Badour et al., 2013a; 2013c).

Notably, debate remains about whether moral disgust truly is a disgust response, or rather a performative expression of anger (Giner-Sorolla, 2021). Whilst my thesis does not directly test—or aim to resolve—this debate, it is an important point to consider. Moral disgust and anger share many similarities: they are negative, arousing and occur in response to moral/social norm violations (Elwood & Olatunji, 2009). These emotions also have differences: moral disgust is associated with an avoidance/rejection response whereas anger is associated with an approach response (Chapman & Anderson, 2012). Furthermore, a person typically feels angry when their own rights are violated and thus, anger functions to re-instate the person's power and rights (Hutcherson & Gross, 2011). In contrast, a person typically feels moral disgust when collective moral norms are violated and thus, moral disgust functions to condemn unacceptable behaviours and exile immoral people from the community (Giner-Sorolla, 2021). In this sense, moral disgust may be a more 'permanent' response; anger is directed to a person's behaviour, whereas moral disgust is directed to the whole person whose actions are perceived as unforgiveable. Nevertheless, despite these nuanced differences, anger and moral disgust typically co-occur (Elwood & Olatunji, 2009; Russell & Giner-Sorolla, 2013). Indeed, in Study 1 I measured people's trauma-related moral disgust and anger; these emotions ('then' and 'now' combined into an average score) were strongly positively correlated (r = .65), suggesting anger and moral disgust often co-occur (or perhaps, often represent the same emotion construct). Given I aimed to understand memory for disgust in the clinical context of trauma and PTS symptoms, I selected fear as a comparison emotion. However, given anger shares similar dimensionality with disgust (particularly moral disgust), future research should examine whether memory differences exist between disgust, fear and anger (using stimuli equated, as closely as possible, on arousal and valence).

7.7 Conclusion

My thesis aimed to address existing research gaps by examining whether disgust memory enhancement—relative to fear—extends to various forms of episodic memory, across a combination of laboratory (i.e., analogue trauma) and real-world (i.e., personal trauma) settings. Overall, disgust memory enhancement extends to *some* forms of memory (i.e., more emotionally intense intrusions over time, more accurate memories and remembering more persistent feelings of disgust). I theorise disgust may be particularly memorable due to the attention-grabbing, highly rehearsed and/or impactful (i.e., visceral and distinctive) nature of disgust stimuli/situations. However, in certain contexts, disgust is comparably memorable to fear (i.e., intrusion characteristics, intrusion frequency and false memories). I argue these findings may be confounded by various factors (e.g., for *personal trauma*, the lack of distinction between disgust and fear; for *analogue trauma*, the fear image set being more interrelated than the disgust image set). My findings fit with both dimensional and discrete accounts of emotion; whilst arousal and valence are necessary components to understanding why emotional situations are remembered better than non-emotional situations, not all negative and arousing emotions (i.e., disgust and fear) are remembered the same. My findings also provide evidence for a unique relationship between disgust and both intrusions and broader PTSD symptoms. These findings suggest disgust should *not* be overlooked as a PTSD-relevant emotion in academic literature, diagnostic tools, clinical practice and public psychoeducation. From an evolutionary standpoint, remembering disgust is useful. However, if disgust sticks in memory more than we want it to, remembering disgust may become harmful and contribute to the development of mental health disorders, like PTSD.

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Appendices

Appendix A: Study 1 and 4a Emotional Reactions Questionnaires

Then:
Thinking about your most stressful or traumatic event from within the past 6 months (i.e., the one you just described), **at the time the event occurred**, how intensely did you feel the following emotions?
Fear: 1 = not at all, 7 = extremely
Disgust: 1 = not at all, 7 = extremely
Anger: 1 = not at all, 7 = extremely
Compassion: 1 = not at all, 7 = extremely

To what extent did you feel **physically disgusted** (e.g., dirty, contaminated, revolted, deformed, diseased) **at the time the event occurred**? (1 = not at all, 7 = extremely)

To what extent did you feel **morally disgusted** (e.g., your/others' rights were violated, you were exposed to behaviour that you consider socially/morally unacceptable/revolting) **at the time the event occurred**? (1 = not at all, 7 = extremely)

Now:
As you think about your most stressful or traumatic event from within the past 6 months (i.e., the one you just described), **at this moment**, how intensely do you feel the following emotions?
Fear: 1 = not at all, 7 = extremely
Disgust: 1 = not at all, 7 = extremely
Anger: 1 = not at all, 7 = extremely
Compassion: 1 = not at all, 7 = extremely

To what extent do you feel **physically disgusted** (e.g., dirty, contaminated, revolted, deformed, diseased) when thinking about the event **at this moment**? (1 = not at all, 7 = extremely)

To what extent do you feel **morally disgusted** (e.g., your/others' rights were violated, you were exposed to behaviour that you consider socially/morally unacceptable/revolting) when thinking about the event **at this moment**? (1 = not at all, 7 = extremely)

Appendix B: Study 1 Involuntary Cognitions Questionnaire

Many people experience memories of a past event that come to mind without them deliberately thinking about it. These memories are called **involuntary memories** and they can be thoughts or images (or a combination of both) of the event. For example, someone who just experienced a car accident can keep seeing images of this experience in their mind. Or someone who has recently lost a loved one may experience spontaneous thoughts and memories about that person, or see images in their mind of the last time they saw that person. It is also possible that when someone experiences an involuntary memory about a particular event, it feels as though the event is happening all over again. What is important here is that the memories come to mind **spontaneously without you deliberately thinking about them**.

We would like you to think back to the event you described earlier in the questionnaire (i.e., **the event from within the past 6 months that bothered you the most**). **Have you experienced any involuntary memories related to that experience within the last month?**

YES NO

Please use the box below to describe the contents (e.g., location, people, event, time) of your most **recent** involuntary memory (e.g., a thought, image or both) related to your most stressful/traumatic event from within the past 6 months.

Rate the following statements as to how well they describe your involuntary memory experience, with regard to **the time you experienced the involuntary memory**.

1. The memory came to mind spontaneously (at the time it occurred).

1	2	3	4	5	6	7
Not at all accurate						Completely accurate

2. I deliberately tried to bring the memory to mind (at the time it occurred).

1	2	3	4	5	6	7
Not at all accurate						Completely accurate

3. When the memory came to mind, it felt intrusive.

1	2	3	4	5	6	7
Not at all accurate						Completely accurate

4. The memory came to mind effortlessly.

1	2	3	4	5	6	7
Not at all accurate						Completely accurate

5. How distressing was the memory?

1	2	3	4	5	6	7
Not at all distressing						Extremely Distressing

6. How vivid was the memory?

1	2	3	4	5	6	7
Not at all vivid						Extremely vivid

7. How unwanted was the memory?

1	2	3	4	5	6	7
Not at all unwanted						Completely unwanted

8. How much did the event feel as though it was happening "right now" when the memory occurred?

1	2	3	4	5	6	7
Not at all						Extremely

9. How intense were the emotions you felt when the memory came to mind?

1	2	3	4	5	6	7
Not at all intense						Extremely intense

10. When the memory came to mind, were the emotions you felt negative or positive?

1	2	3	4	5	6	7
Extremely negative						Extremely positive

Appendix C: Study 4b Emotional Reactions Questionnaires

Time 1 Then:

Thinking about your most stressful or traumatic event from within the past 3 months (i.e., the one you just described), **at the time the event occurred**, how intensely did you feel the following emotions?

Fear: 1 = not at all, 7 = extremely
Disgust: 1 = not at all, 7 = extremely
Anger: 1 = not at all, 7 = extremely
Sad: 1 = not at all, 7 = extremely
Compassion: 1 = not at all, 7 = extremely
Relaxed: 1 = not at all, 7 = extremely
Hope: 1 = not at all, 7 = extremely
Strong: 1 = not at all, 7 = extremely

Thinking about your most stressful or traumatic event from within the past 3 months (i.e., the one you just described), **at the time the event occurred**, how unpleasant or pleasant did you feel? (1 = extremely unpleasant, 7 = extremely pleasant)

Time 1 Now:

As you think about your most stressful or traumatic event from within the past 3 months (i.e., the one you just described), **at this moment**, how intensely do you feel the following emotions?

Fear: 1 = not at all, 7 = extremely
Disgust: 1 = not at all, 7 = extremely
Anger: 1 = not at all, 7 = extremely
Sad: 1 = not at all, 7 = extremely
Compassion: 1 = not at all, 7 = extremely
Relaxed: 1 = not at all, 7 = extremely
Hope: 1 = not at all, 7 = extremely
Strong: 1 = not at all, 7 = extremely

As you think about your most stressful or traumatic event from within the past 3 months (i.e., the one you just described), **at this moment**, how unpleasant or pleasant do you feel? (1 = extremely unpleasant, 7 = extremely pleasant)

Time 2 Now:
As you think about the traumatic/stressful event you previously described (during Part 1 of the study), **at this moment**, how intensely do you feel the following emotions?
Fear: 1 = not at all, 7 = extremely
Disgust: 1 = not at all, 7 = extremely
Anger: 1 = not at all, 7 = extremely
Sad: 1 = not at all, 7 = extremely
Compassion: 1 = not at all, 7 = extremely
Relaxed: 1 = not at all, 7 = extremely
Hope: 1 = not at all, 7 = extremely
Strong: 1 = not at all, 7 = extremely

As you think about the traumatic/stressful event you previously described (during Part 1 of the study), **at this moment**, how unpleasant or pleasant do you feel? (1 = extremely unpleasant, 7 = extremely pleasant)

Appendix D: Study 2a Image Stimuli (as in Chapman, 2018)

Emotion	**ID**	**Database/Source**	**Description**
Disgust	D_101	Chapman (2018)	Stitched leg
Disgust	D_170	Chapman (2018)	Dirty nappy
Disgust	D_019	Chapman (2018)	Blood nose
Disgust	D_045	Chapman (2018)	Faeces on toilet seat
Disgust	D_090	Chapman (2018)	Rubbish
Disgust	D_147	Chapman (2018)	Clubfoot
Disgust	D_004	Chapman (2018)	C-section birth
Disgust	D_057	Chapman (2018)	Teeth with blood
Disgust	D_066	Chapman (2018)	Face covered in piercings
Disgust	D_070	Chapman (2018)	Bloody feet
Disgust	D_119	Chapman (2018)	Mould
Disgust	D_153	Chapman (2018)	Old burger
Disgust	D_122	Chapman (2018)	Worms
Disgust	D_144	Chapman (2018)	Beetle
Fear	F_230	Chapman (2018)	Armed group of people surrounding a car
Fear	F_027	Chapman (2018)	Snake
Fear	F_036	Chapman (2018)	Spider
Fear	F_087	Chapman (2018)	Soldier
Fear	F_106	Chapman (2018)	Police chasing man
Fear	F_122	Chapman (2018)	Plane crash
Fear	F_146	Chapman (2018)	Person throwing molotov
Fear	F_165	Chapman (2018)	Hostage
Fear	F_174	Chapman (2018)	Bushfire
Fear	F_179	Chapman (2018)	Pointing gun
Fear	F_195	Chapman (2018)	Dog growling
Fear	F_212	Chapman (2018)	Person drowning
Fear	F_217	Chapman (2018)	Bomb
Fear	F_234	Chapman (2018)	Shipwreck
Neutral	N_019	Chapman (2018)	Basket
Neutral	N_027	Chapman (2018)	Boats
Neutral	N_031	Chapman (2018)	Satellite
Neutral	N_033	Chapman (2018)	City skyline

Neutral	N_042	Chapman (2018)	Joggers in park
Neutral	N_050	Chapman (2018)	Car
Neutral	N_052	Chapman (2018)	Iron
Neutral	N_064	Chapman (2018)	Grass
Neutral	N_066	Chapman (2018)	Jacket
Neutral	N_078	Chapman (2018)	Keys
Neutral	N_080	Chapman (2018)	Eggs
Neutral	N_102	Chapman (2018)	Train
Neutral	N_115	Chapman (2018)	Line of trees
Neutral	N_116	Chapman (2018)	Igloo

Appendix E: Study 2b Image Stimuli

Emotion	ID	Database	Description
Disgust	Objects_006_h	NAPS	Raw meat
Disgust	Disgust57	Grootswager et al. (2020)	Rotten teeth
Disgust	Animals_017_v	NAPS	Dead bird
Disgust	Disgust10	Grootswager et al. (2020)	Dead boar
Disgust	Disgust18	Grootswager et al. (2020)	Mouldy bread
Disgust	Disgust72	Grootswager et al. (2020)	Worms
Disgust	Animals_075_h	NAPS	Mouse with an incision on stomach
Disgust	D_101	Chapman (2018)	Stitched leg
Disgust	D_170	Chapman (2018)	Dirty nappy
Disgust	D_019	Chapman (2018)	Blood nose
Disgust	D_045	Chapman (2018)	Faeces on toilet seat
Disgust	D_090	Chapman (2018)	Rubbish
Disgust	D_147	Chapman (2018)	Clubfoot
Disgust	People_209_v	NAPS	Surgery
Fear	Objects_001_h	NAPS	Car on fire
Fear	Fear1	Grootswager et al. (2020)	Man tied in rope
Fear	Fear6	Grootswager et al. (2020)	Snake
Fear	Fear20	Grootswager et al. (2020)	Gun pointed at screen
Fear	Fear29	Grootswager et al. (2020)	Hostage
Fear	Fear68	Grootswager et al. (2020)	Vampire
Fear	Fear45	Grootswager et al. (2020)	Man pointing gun at self
Fear	Fear53	Grootswager et al. (2020)	Girl screaming
Fear	Animals_069_h	NAPS	Spider
Fear	Fear70	Grootswager et al. (2020)	Clown
Fear	People_124_h	NAPS	Man getting arrested
Fear	Objects_139_h	NAPS	Doll head
Fear	F_146	Chapman (2018)	Person throwing molotov
Fear	F_230	Chapman (2018)	Armed group of people surrounding a car
Neutral	N_031	Chapman (2018)	Satellite
Neutral	Neutral79	Grootswager et al. (2020)	Dancers
Neutral	N_080	Chapman (2018)	Eggs

Neutral	N_042	Chapman (2018)	Joggers in park
Neutral	N_078	Chapman (2018)	Keys
Neutral	N_102	Chapman (2018)	Train
Neutral	N_115	Chapman (2018)	Line of trees
Neutral	Neutral63	Grootswager et al. (2020)	Construction workers
Neutral	Neutral32	Grootswager et al. (2020)	People in the snow
Neutral	Neutral15	Grootswager et al. (2020)	Woman using a telephone
Neutral		Chapman (2018)	Basket
Neutral	N_066	Chapman (2018)	Jacket
Neutral	N_050	Chapman (2018)	Car
Neutral	N_052	Chapman (2018)	Iron

Appendix F: Study 3 Image Stimuli

Emotion	**ID**	**Database/Source**	**Description**
		Disgust Pair Set 1	
Disgust	Disgust42	Grootswager et al. (2020)	Deceased animal head
Disgust	Disgust18	Grootswager et al. (2020)	Moldy bread
Disgust	Cockroach 1	OASIS	Cockroach
Disgust	1262_hygiene	DIRTI	Hair in drain
Disgust	People_243_h	NAPS	Bloodshot eye
Disgust	Disgust68	Grootswager et al. (2020)	Leeches
Disgust	Disgust35	Grootswager et al. (2020)	Maggots
Disgust	b11_p167_11	SMID	Roadkill animal
Disgust	Garbage dump 4	OASIS	Rubbish
Disgust	EM0695	EmoMadrid	Scab
Disgust	Disgust80	Grootswager et al. (2020)	Surgery
Disgust	EM0698	EmoMadrid	Rotten teeth

Emotion	**ID**	**Database/Source**	**Description**
		Disgust Pair Set 2	
Disgust	Disgust7	Grootswager et al. (2020)	Deceased animal head
Disgust	Disgust19	Grootswager et al. (2020)	Moldy bread
Disgust	EM0726	EmoMadrid	Cockroach
Disgust	1287_hygiene	DIRTI	Hair in drain
Disgust	Tumor 1	OASIS	Bloodshot eye
Disgust	Disgust14	Grootswager et al. (2020)	Leeches

Disgust	Disgust50	Grootswager et al. (2020)	Maggots
Disgust	Disgust60	Grootswager et al. (2020)	Roadkill animal
Disgust	Landscapes_026_h	NAPS	Rubbish
Disgust	EM0724	EmoMadrid	Scab
Disgust	People_209_v	NAPS	Surgery
Disgust	Disgust62	Grootswager et al. (2020)	Rotten teeth

Emotion	**ID**	**Database/Source**	**Description**
		Disgust Unrelated Set 3	
Disgust	Objects_006_h	NAPS	Raw meat
Disgust	Animals_008_v	NAPS	Chicken missing feathers
Disgust	Disgust15	Grootswager et al. (2020)	Deformed foot
Disgust	D_019	Chapman (2018)	Blood nose
Disgust	Disgust27	Grootswager et al. (2020)	Dirty toilet
Disgust	Animals_037_h	NAPS	Tick
Disgust	Disgust59	Grootswager et al. (2020)	Vomit
Disgust	b15_p310_3	SMID	Cricket covered in ants
Disgust	EM0616	EmoMadrid	Mouse intestines
Disgust	EM0755	EmoMadrid	Cigarettes
Disgust	Animal carcass 6	OASIS	Lions feeding on a deceased zebra
Disgust	Severed finger 1	OASIS	Bloody finger

Emotion	**ID**	**Database/Source**	**Description**
		Fear Pair Set 1	
Fear	Faces_018_h	NAPS	Young boys armed with weapons

Fear	2692	Chapman (2018)	Bomb
Fear	EM0786	EmoMadrid	Car on fire
Fear	EM0722	EmoMadrid	Clown
Fear	EM0390	EmoMadrid	Written-off vehicle (post-collision)
Fear	EM0819	EmoMadrid	Bushfire
Fear	Fear30	Grootswager et al. (2020)	Gun pointed at a woman
Fear	Fear90	Grootswager et al. (2020)	Person holding a knife
Fear	Fear38	Grootswager et al. (2020)	Hostage
Fear	Fear56	Grootswager et al. (2020)	Scary face
Fear	F_027	Chapman (2018)	Snake
Fear	F_036	Chapman (2018)	Spider

Emotion	**ID**	**Database/Source**	**Description**
		Fear Pair Set 2	
Fear	Fear82	Grootswager et al. (2020)	Young boys armed with weapons
Fear	b2_p21_7	SMID	Bomb
Fear	Objects_001_h	NAPS	Car on fire
Fear	Fear70	Grootswager et al. (2020)	Clown
Fear	People_016_h	NAPS	Written-off vehicle (post-collision)
Fear	F_174	Chapman (2018)	Bushfire
Fear	Fear42	Grootswager et al. (2020)	Gun pointed at a woman
Fear	Fear3	Grootswager et al. (2020)	Person holding a knife
Fear	F_165	Chapman (2018)	Hostage
Fear	Fear59	Grootswager et al. (2020)	Scary face

Fear	Fear2	Grootswager et al. (2020)	Snake
Fear	EM0090	EmoMadrid	Spider

Emotion	**ID**	**Database/Source**	**Description**
		Fear Unrelated Set 3	
Fear	Fear40	Grootswager et al. (2020)	Growling bear
Fear	Fear34	Grootswager et al. (2020)	Home invasion
Fear	Fear13	Grootswager et al. (2020)	Shark
Fear	Fear53	Grootswager et al. (2020)	Girl screaming
Fear	Fear9	Grootswager et al. (2020)	Person wearing balaclava
Fear	Fear5	Grootswager et al. (2020)	Growling dog
Fear	Fear84	Grootswager et al. (2020)	Soldier pointing a gun
Fear	F_106	Chapman (2018)	Police chasing man
Fear	People_127_h	NAPS	Physical assault
Fear	6821	Chapman (2018)	Armed group of people surrounding a car
Fear	b15_p439_16	SMID	Domestic violence
Fear	EM0487	EmoMadrid	Person holding a knife against someone else's throat

Emotion	**ID**	**Database/Source**	**Description**
		Neutral Unrelated Set 1	
Neutral	N_027	Chapman (2018)	Boats
Neutral	Neutral23	Grootswager et al. (2020)	Young boy
Neutral	N_050	Chapman (2018)	Car
Neutral	Neutral47	Grootswager et al. (2020)	

Emotion	ID	Database/Source	Description
Neutral	N_115	Chapman (2018)	Line of trees
Neutral	N_116	Chapman (2018)	Igloo
Neutral	Neutral63	Grootswager et al. (2020)	Construction workers
Neutral	Neutral45	Grootswager et al. (2020)	Businesspeople
Neutral	Neutral32	Grootswager et al. (2020)	People in the snow
Neutral	Neutral15	Grootswager et al. (2020)	Woman using a telephone
Neutral	N_066	Chapman (2018)	Jacket
Neutral	Neutral69	Grootswager et al. (2020)	Violinist

Emotion	ID	Database/Source	Description
		Neutral Unrelated Set 2	
Neutral	N_019	Chapman (2018)	Basket
Neutral	Neutral28	Grootswager et al. (2020)	Two people sat at a table
Neutral	N_031	Chapman (2018)	Satellite
Neutral	N_064	Chapman (2018)	Grass
Neutral	Neutral79	Grootswager et al. (2020)	Dancers
Neutral	N_080	Chapman (2018)	Eggs
Neutral	N_033	Chapman (2018)	City skyline
Neutral	N_042	Chapman (2018)	Joggers in park
Neutral	N_052	Chapman (2018)	Iron
Neutral	Neutral66	Grootswager et al. (2020)	Boy playing chess
Neutral	N_078	Chapman (2018)	Keys
Neutral	N_102	Chapman (2018)	Train

Note. NAPS: the Nencki Affective Picture System (Marchewka et al., 2014); SMID: the Socio-Moral Image Database (Crone et al., 2018); EmoMADRID Database (Carretié et al., 2019); OASIS: the Open Affective Standardized Image Set (Kurdi et al., 2016).

Appendix G: Image Rating Scales

<u>Studies 2a, 2b and 3</u>
How *emotionally arousing* is this image? (1 = not at all, 7 = highly)
How *disgusting* is this image? (1 = not at all disgusting, 7 = extremely disgusting)
How *frightening* is this image? (1 = not at all frightening, 7 = extremely frightening)

<u>Study 2a only</u>
How *pleasant* would you rate this image? (1 = extremely unpleasant, 7 = extremely pleasant)

<u>Studies 2b and 3</u>
How *pleasant* would you rate this image? (1 = not at all, 7 = extremely)
How *unpleasant* would you rate this image? (1 = not at all, 7 = extremely)
How *distinctive* (unusual/eye-catching) would you rate this image? (1 = not at all distinctive, 7 = extremely distinctive)

<u>Study 3 only</u>
Instructions for similarity ratings
You will be shown pairs of photos, some of which are graphic and negative in nature. Please rate each pair of photos on their similarity (i.e., how close the resemblance is between the two images in the pair).
Scale: How *similar* would you rate these two images? (1 = not very similar, 7 = very similar)

Instructions for organisation ratings
Look at the pair of images below and consider how **related** the content between each image is. Images can be related because:
- They are part of <u>the same category</u> (e.g., a chair and a table are both an example of furniture)
- They are <u>thematically related</u> (e.g., rain and an umbrella)
- Or, because <u>one item in the image brings to mind another item in the other image</u> (e.g., a bow brings to mind an arrow).

In answering this question, please ignore superficial similarities between the images (e.g., colour or layout).
Scale: How *related* is the content of these two images? (1 = low relatedness, 7 = high relatedness)

Appendix H: Study 2 Intrusion/Thought Monitoring Task Instructions and Booklets

In-Lab Thought Monitoring Instructions:

Many people have the experience where the memory of a past experience comes to mind without them deliberately thinking about it. These can be positive as well as negative experiences, and the memories might be thoughts or images. For example, someone who just experienced a car accident can keep seeing images of this experience in their mind. What is important here is that the memories come to mind spontaneously without you deliberately thinking about them. When completing the vigilance task you may find yourself experiencing these kinds of INVOLUNTARY memories about the photos you have just seen. If an involuntary memory of any photo you have just seen comes to your mind, please press the X key. Pressing the X key will stop the vigilance task and you will be prompted to fill out details of the involuntary memory in this booklet. Please fill out a separate page for each involuntary memory that you experience. It is important that you only press the X key if one of the photos comes to mind INVOLUNTARILY: where it happens without you meaning to think about it. Please also remember to press the X key EVERY TIME you experience an involuntary memory of the photos you viewed earlier – even if you have already experienced the same memory. You will be instructed, on screen, how to return to the vigilance task. This phase will end once 8 minutes have passed regardless of how many times you press the X key.

As a reminder, when you see a vertical line pattern press the space bar. Remember to also press the X key *every time* you experience an involuntary cognition and to fill out the booklet. Press “n” when you are ready to begin, and ring the doorbell once the task has ended.

In-Lab Thought Monitoring Booklet:

Please use the box below to describe, in a few words, the photo that involuntarily came to mind.

1. How easily did the photo come to mind?

1 2 3 4 5

Not at all Extremely

2. How intense were the emotions you felt when the photo came to mind?

1 2 3 4 5

Not at all Extremely

Please turn the page then continue with the monitoring task by pressing the “n” key

Diary Thought Monitoring Booklet Title Page:

Please carry this thought monitoring booklet with you over the next **24 hours** (after completing Part 1 of the Reactions to Emotional Material study).
If you experience any *involuntary* memories of the photos you viewed during the study today, please fill out a page of the booklet.

- It is important that you only fill out a page if one of the photos comes to mind INVOLUNTARILY: where it happens without you meaning to think about it.
- Please monitor these memories over the next 24 hours and fill out a separate page for each involuntary memory that you experience, including if you experience the same memory more than once.
- After 24 hours, you will receive an email with a link for you to complete an online survey. The survey contains several questionnaires, one of which asks about a negative personal experience. The survey will take you about 30 minutes to complete.
- At the end of the survey, you will receive debrief information as you would have completed both parts of the study.

Please return your thought monitoring booklet to the lab after you have completed the study.

Diary Thought Monitoring Booklet:

Please use the box below to describe, in a few words, the photo that involuntarily came to mind.

3. How easily did the photo come to mind?

1	2	3	4	5
Not at all				Extremely

4. How intense were the emotions you felt when the photo came to mind?

1	2	3	4	5
Not at all				Extremely

Please keep this booklet on you at all times for 24-hours following the lab session for the 'Reactions to Emotional Material' study

Appendix I: Study 2 Involuntary Cognitions Questionnaire

Rate the following statements as to how well they describe, on average, your experience of the photos coming to mind in a way that led you to press the spacebar.

11. I deliberately tried to bring the photos I viewed earlier to mind

1	2	3	4	5	6	7
Not at all accurate						Completely accurate

12. I intended to bring the photos I viewed earlier to mind

1	2	3	4	5	6	7
Not at all accurate						Completely accurate

13. When the photos I viewed earlier came to mind, they felt intrusive

1	2	3	4	5	6	7
Not at all accurate						Completely accurate

14. The photos I viewed earlier came to mind spontaneously

1	2	3	4	5	6	7
Not at all accurate						Completely accurate

15. The photos I viewed earlier came to mind effortlessly

1	2	3	4	5	6	7
Not at all accurate						Completely accurate

16. It was easy to bring the photos I viewed earlier to mind

1	2	3	4	5	6	7
Not at all accurate						Completely accurate

17. I tried hard to bring the photos I viewed earlier to mind

1	2	3	4	5	6	7
Not at all accurate						Completely accurate

18. On average, how distressing were the memories for the photos you viewed earlier?

1	2	3	4	5	6	7
Not at all distressing						Extremely Distressing

19. On average, how vivid were the memories of the photos you viewed earlier?

1	2	3	4	5	6	7
Not at all vivid						Extremely vivid

20. To what extent were the memories of the photos you viewed earlier unwanted?

1	2	3	4	5	6	7
Not at all unwanted						Completely unwanted

21. How intense were the emotions you felt when the photos you viewed earlier came to mind?

1	2	3	4	5	6	7
Not at all intense						Extremely intense

22. While having the memories of the photos you viewed earlier, were the emotions you felt negative or positive?

1	2	3	4	5	6	7
Extremely negative						Extremely positive

Appendix J: Study 3 Recognition Test Instructions

Next, you will be shown a series of images one at a time. For each image, you will be asked if the photo is OLD or NEW.

Please select the OLD button if you saw the image yesterday in Session 1 of this study. Please select the NEW button if you did not see the image yesterday in Session 1 of this study.

Then, please rate your confidence in your decision for each image.

Sometimes you may be asked to identify if you REMEMBER or KNOW viewing that image.

Recognition memory often brings back to mind the context you first experienced. For example, you might recognise someone's face, and explicitly remember talking to this person at a party last week. At other times, you may recognise something and have a vague feeling that you have had prior exposure to it, but nothing comes to mind about the context. For example, someone’s face feels familiar, but you have no explicit recollection of seeing this person before.

For this study, please select REMEMBER if you recognise the image as one you saw yesterday in Session 1 of this study, and explicitly remember something you thought or experienced when the image appeared then. Alternatively, please select KNOW for each image that seems familiar, but you do not explicitly recall viewing it yesterday in Session 1 of this study.

Appendix K: Trauma History Screen (THS; Carlson et al., 2011)

As used in Studies 1 and 4a

The events below may or may not have happened to you **within the last 6 months**. Read each event and then select the events that have happened to you **within the last 6 months**. If you select any events, put a number in the blank box below it indicating the number of times something like that happened.

			Number of times something like this has happened
A. A really bad car, boat, train, or airplane accident	YES	NO	
B. A really bad accident at work or home	YES	NO	
C. A hurricane, flood, earthquake, tornado, or fire	YES	NO	
D. Hit or kicked hard enough to injure - as an adult	YES	NO	
E. Forced or made to have sexual contact - as an adult	YES	NO	
F. Attack with a gun, knife, or weapon	YES	NO	
G. During military service - seeing something horrible or being badly scared	YES	NO	
H. Sudden death of close family or friend	YES	NO	
I. Seeing someone die suddenly or get badly hurt or killed	YES	NO	
J. Some other sudden event that made you feel very scared, helpless, or horrified	YES	NO	
K. Sudden move or loss of home and possessions	YES	NO	
L. Suddenly abandoned by spouse, partner, parent, or family	YES	NO	

If you selected any of the events above, did any of these things really bother you emotionally?

YES NO I did not experience any of the events above

If 'yes': Briefly describe (in one or two sentences) the event that bothered you the most (i.e., your most traumatic experience **within the past 6 months**) in the box below. We are going to ask you a number of questions about this event.

If 'no' or 'I did not experience any of the events above': Briefly describe (in one or two sentences) the most stressful experience you have experienced **within the past 6 months** in the box below. We are going to ask you a number of questions about this event.

Approximately how long ago did this event happen? If you experienced the trauma/stressful event over a prolonged period, please report when the trauma/stressful event started.

________ months ________ days

When this happened did anyone get hurt or killed?

YES NO

When this happened, were you afraid that you or someone else might get hurt or killed?

YES NO

When this happened did you feel very afraid, hopeless, or horrified?

YES NO

After this happened, how long were you bothered by it?

- Not at all
- 1 week
- 2-3 weeks
- A month or more

How much did it bother you emotionally?

- Not at all
- A little
- Somewhat
- Much
- Very much

<u>Note:</u> *Changes made for Study 4b:*

- *Event time changed from within the past 6 months to within the past 3 months*
- *Event Category J removed*
- *When asking for a brief description of the event, the following item was also shown: Please write a **short title** for this event. We will use this title in Part 2 of the study to remind you of your event.*
- *Time since the event changed from 'months' and 'days' specification to a calendar response*

Appendix L: The Posttraumatic Stress Disorder Checklist (PCL-5; Weathers et al., 2013)

Below is a list of problems that people sometimes have in response to a very stressful experience. Keeping the traumatic/stressful event you previously described in mind, please read each problem carefully and then select the number that best indicates how much you have been bothered by that problem <u>in the past month</u>.

1. Repeated, disturbing, and unwanted memories of the stressful experience?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

2. Repeated, disturbing dreams of the stressful experience?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

3. Suddenly feeling or acting as if the stressful experience were actually happening again (as if you were actually back there reliving it)?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

4. Feeling very upset when something reminded you of the stressful experience?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

5. Having strong physical reactions when something reminded you of the stressful experience (for example, heart pounding, trouble breathing, sweating)?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

6. Avoiding memories, thoughts, or feelings related to the stressful experience?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

7. Avoiding external reminders of the stressful experience (for example, people, places, conversations, activities, objects, or situations)?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

8. Trouble remembering important parts of the stressful experience?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

9. Having strong negative beliefs about yourself, other people, or the world (for example, having thoughts such as: I am bad, there is something seriously wrong with me, no one can be trusted, the world is completely dangerous)?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

10. Blaming yourself or someone else for the stressful experience or what happened after it?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

11. Having strong negative feelings such as fear, horror, anger, guilt, or shame?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

12. Loss of interest in activities that you used to enjoy?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

13. Feeling distant or cut off from other people?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

14. Trouble experiencing positive feelings (for example, being unable to feel happiness or have loving feelings for people close to you)?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

15. Irritable behaviour, angry outbursts, or acting aggressively?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

16. Taking too many risks or doing things that could cause you harm?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

17. Being “superalert” or watchful or on guard?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

18. Feeling jumpy or easily startled?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

19. Having difficulty concentrating?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

20. Trouble falling or staying asleep?

0	1	2	3	4
Not at all	A little bit	Moderately	Quite a bit	Extremely

Appendix M: Disgust Propensity and Sensitivity Scale – Revised (DPSS-R; van Overveld et al., 2010)

This questionnaire consists of 12 statements about disgust. Please read each statement and think how often it is true for you, then place a 'x' in the box that is closest to this.

Scoring key: never = 1, rarely = 2, sometimes = 3, often = 4, always = 5.

Disgust propensity: sum of items 1, 4, 5, 6, 8, 10.
Disgust sensitivity: sum of items 2, 3, 7, 9, 11, 12.

	1 Never	2 Rarely	3 Sometimes	4 Often	5 Always
1. I avoid disgusting things					
2. When I feel disgusted, I worry that I might pass out					
3. It scares me when I feel nauseous					
4. I feel repulsed					
5. Disgusting things make my stomach turn					
6. I screw up my face in disgust					
7. When I notice that I feel nauseous, I worry about vomiting					
8. I experience disgust					
9. It scares me when I feel faint					
10. I find something disgusting					
11. It embarrasses me when I feel disgusted					
12. I think feeling disgust is bad for me					

Note. In Study 1 I used Goetz et al.'s (2013) adaptation of this scale which omits items 11 and 12

Appendix N: The Moral Disgust Subscale of the Three Domains of Disgust Scale (TDDS; Tybur et al., 2009)

The following items describe a variety of concepts. Please rate how disgusting you find the concepts described in the items, where 0 means that you do not find the concept disgusting at all, and 6 means that you find the concept extremely disgusting.

	0 Not at all disgusting	1	2	3	4	5	6 Extremely disgusting
Shoplifting a candy bar from a convenience store							
Stealing from a neighbor							
A student cheating to get good grades							
Deceiving a friend							
Forging someone's signature on a legal document							
Cutting to the front of a line to purchase the last few tickets to a show							
Intentionally lying during a business transaction							

Appendix O: Disgust Scale – Revised (Olatunji et al., 2007c)

Please indicate how much you agree with each of the following statements, or how true it is about you. Please write a number (0-4) to indicate your answer:

0 = Strongly disagree (very untrue about me)
1 = Mildly disagree (somewhat untrue about me)
2 = Neither agree nor disagree
3 = Mildly agree (somewhat true about me)
4 = Strongly agree (very true about me)

____1. I might be willing to try eating monkey meat, under some circumstances.
____2. It would bother me to be in a science class, and to see a human hand preserved in a jar.
____3. It bothers me to hear someone clear a throat full of mucous.
____4. I never let any part of my body touch the toilet seat in public restrooms.
____5. I would go out of my way to avoid walking through a graveyard.
____6. Seeing a cockroach in someone else's house doesn't bother me.
____7. It would bother me tremendously to touch a dead body.
____8. If I see someone vomit, it makes me sick to my stomach.
____9. I probably would not go to my favorite restaurant if I found out that the cook had a cold.
____10. It would not upset me at all to watch a person with a glass eye take the eye out of the socket.
____11. It would bother me to see a rat run across my path in a park.
____12. I would rather eat a piece of fruit than a piece of paper
____13. Even if I was hungry, I would not drink a bowl of my favorite soup if it had been stirred by a used but thoroughly washed flyswatter.
____14. It would bother me to sleep in a nice hotel room if I knew that a man had died of a heart attack in that room the night before.

How disgusting would you find each of the following experiences? Please write a number (0-4) to indicate your answer:

0 = Not disgusting at all
1 = Slightly disgusting
2 = Moderately disgusting
3 = Very disgusting
4 = Extremely disgusting

____15. You see maggots on a piece of meat in an outdoor garbage pail.
____16. You see a person eating an apple with a knife and fork
____17. While you are walking through a tunnel under a railroad track, you smell urine.
____18. You take a sip of soda, and then realize that you drank from the glass that an acquaintance of yours had been drinking from.
____19. Your friend's pet cat dies, and you have to pick up the dead body with your bare hands.
____20. You see someone put ketchup on vanilla ice cream, and eat it.
____21. You see a man with his intestines exposed after an accident.
____22. You discover that a friend of yours changes underwear only once a week.
____23. A friend offers you a piece of chocolate shaped like dog-doo.
____24. You accidentally touch the ashes of a person who has been cremated.
____25. You are about to drink a glass of milk when you smell that it is spoiled.
____26. As part of a sex education class, you are required to inflate a new unlubricated condom, using your mouth.
____27. You are walking barefoot on concrete, and you step on an earthworm.

Appendix P: Disgust Avoidance Questionnaire (von Spreckelsen et al., 2022)

This questionnaire will assess how people cope with situations or activities that can elicit disgust, for example: coming into contact with bodily fluids of another person, accidentally eating rotting food, seeing mutilated bodies on the TV, witnessing dehumanization or harm done to others. For each of the statements presented below, pleased indicate the extent to which you agree or disagree with the statements.

1. I try to avoid activities that could make me feel disgusted

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

2. When I think about something gross, I push those thoughts out of my mind

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

3. I am quick to stop any activity that makes me feel disgusted

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

4. I try not to think about gross situations

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

5. When thoughts about repulsive things come up, I try very hard to stop thinking about them

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

6. I avoid actions that remind me of repulsive things

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

7. If I start feeling strong disgust, I prefer to leave the situation

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

8. If thoughts about disgusting things cross my mind, I try to push them away as much as possible

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

9. I try hard to avoid thinking about a repulsive past situation

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

10. I try hard to avoid situations that might bring up feelings of repulsion in me

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

11. If I am in a situation in which I feel revolted, I leave the situation immediately

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

12. When thoughts about revolting things come up, I try to fill my head with something else

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

13. I avoid certain situations that make me pay attention to disgusting things

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

14. I distract myself to avoid thinking about things that disgust me

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

15. I am quick to leave any situation that makes me feel disgusted

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

16. I avoid objects that can trigger feelings of disgust

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

17. To avoid thinking about things that revolt me, I force myself to think about something else

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree