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A Repulsive Inquiry: Evaluating the impact of cognitive load on aversive gaze behaviors following exposure to disgusting and fearful stimuli

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Dedicated to J'Emma. Your everlasting patience, love, support, and newspaper 'funnies' kept me smiling through the coldest Northeast winters.

Rest in Peace

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Thank you to my mother for fueling my passions and never giving up on me.

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Abstract

The present study analyzed the impact of gaze behavior in response to disgusting, fearful, and neutral pictures while participants operate under a cognitive load. Participants were exposed to fearful and disgusting stimuli and their eye movements were tracked accordingly. Participants were randomly sorted into either the cognitive load or no-cognitive load groups. Those within the cognitive load group were given a 5-digit memorization task before each of the four trial sets while the no cognitive load group received a break (in the form of a blank screen) instead. After completing the free-viewing task, participants from both groups were prompted to evaluate each of the disgusting and fearful pictorial stimuli on scales for measures of disgustingness, fearfulness, and arousal. Participants subjected to a cognitive load during the free-viewing task showed significantly shorter initial dwell times on disgusting and fearful stimuli than participants that did not receive a cognitive load. However, there was no significant difference in initial dwellings between the fearful and disgusting stimuli themselves. Furthermore, the disgust ratings did not predict longer or shorter dwell times on corresponding disgust stimuli, nor did the fear ratings predict longer or shorter dwell times on fearful stimuli. These findings indicate cognitive load as playing a key role in disgust evaluation and resilience thereof, pointing to working memory capacity as the key resource fueling these interactions and dwellings.

Keywords: disgust, fear, eye-tracking, gaze behavior, cognitive load, digit memorization task

Disgust

In his 1941 essay on disgust and other aversions, Andras Angyal distinguishes disgust by first investigating the objects that incur and elicit this aversive sentiment. He asserts that many of the eliciting objects fall under the umbrella of excreta or wastes produced by humans and other animals, namely fecal matter, vomit, and blood. Disgust is a cognitive and behavioral response to the perceived threat of these elicitors and has effectively shaped many societal norms and standards. Taking waste products as an example, with its repugnant odor and potential microbial danger societal qualifiers deem it as impure and measures like sewers systems have been put in place to ensure efficient disposal with minimal human contact. Coming into contact with fecal matter or any other excreta is considered dirtying as it pollutes and soils the afflicted person (Angyal, 1941). This contamination is further manipulated by the degree of contact: the more extreme the contact, the more contaminated the individual becomes. This contact can range from a minimal degree, such as standing within the vicinity of the disgusting object, to an extreme degree, such as an oral ingestion. Angyal (1941) also asserts that the intensity of the response would be positively correlated to the degree of contact such that the relative disgust response to ingestion of fecal matter, a rather extreme form of contact, would elicit a more disgusted response than stepping in dog poop, a contact easily remedied by a washing of one's shoe. Further impacting the degree of contact is the type and degree of sensory experience. Disgust is an emotion elicited through all five senses, yet even in instances of isolated single-sense experiences such as the sight of blood from a cut or the scent of the sewers on a hot day, a disgust response is still observed (Haberkamp et al., 2017; Wicker et al., 2003).

The rationalization of disgust, wherein one may argue disgust simply to be a fear of bacteria or other potentially harmful microorganisms present in the excreta or mold, is secondary and null as disgust has been proven to be present even in those without the knowledge of microorganisms (Angyal, 1941). This points to disgust being, like fear, an instinctual reaction, one that is disconnected from rational, cognitive thought and is driven by sometimes unexplainable revulsions towards aforementioned sensory inputs such as particularly pungent smells, uncomfortable textures, or unpalatable tastes. Opposite to initial reactions to fearful stimuli, in which instinctual facial-muscular responses serve to increase sensory intake, initial responses to disgust include the narrowing nostrils, the closing of the mouth, and closing or averting one's eyes (Susskind et al., 2008). Angyal takes note of such motor reactions and argues that they function mainly as a method of avoiding exposure or ingestion as indicated by tightening or downturn of the lips to refuse entry or promote expulsion respectively. In his observations, Angyal also notes that an experience of disgust while an individual is eating or drinking leads to a difficulty or inability to swallow properly, illustrating the body's instinct to refuse potential contaminants.

More recently, another theory has arisen regarding the motivation behind such elusive behaviors. It asserts that emotional regulation, defined as "the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions", plays a significant role in moderating gaze aversion and associated escapism (Cisler & Koster, 2010, p12; Gross, 1998). Such avoidant behavior may range from simply averting one's gaze from a particularly violent scene in a movie to procrastinating work because it's overwhelming and stressful. But, regardless of the context, the common goal in every instance is to reduce the emotional turmoil and anxiety experienced by the individual. Needless to say, disgusting and fearful imagery are prime examples of such emotionally deregulating stimuli and, accordingly, arouse similarly avoidant and distractor behaviors. As seen within recent disgust testing, visual stimuli are able to effectively elicit feelings of disgust and fear (Haberkamp et al. 2017, Armstrong et al., 2022, Carretié et al., 2011). With technologies such as eye tracking employed within the following study, precise measurements of these tendencies can be recorded and analyzed to better understand the mechanisms driving such cognitive processes. In doing so, we are able to garner a deeper understanding of the avenues by which we interact with the insurmountably gross, terrifying, and beautiful world around us.

Subsets of Disgust

Sex and Disgust

Although he asserted excreta to be the most common and universal elicitor of disgust, Angyal also takes note of what he calls "other aversions" namely towards sex and towards food, and posits them to be distinct from, but not unrelated to disgust towards excreta (Angyal, 1941, p403-10). There are numerous excreta that are associated with and are essential in procreation. Seminal fluid is, of course, necessary for the process of impregnation, while other secretions are necessary for facilitating this process. Secondary excreta such as sweat, sputum, and blood fall into this category as well. As a result of their association with the act of sex and the pleasure it brings, excreta involved in intercourse are positively valenced. Angyal refers to a theory presented by Kafka in his 1930 essay *Zur Psychologie des Ekels* in which he proposes a mechanism called "inversion" whereby objects of revulsion become objects of attraction in the case of sexual arousal (Angyal, 1941, p405-6). Angyal, notes that individuals, with regard to "inversion" lie on a spectrum; some individuals take inversion to the extreme, their attraction growing to target excreta specifically, while others are seemingly incapable of such "inversion", remaining disgusted of excreta even in sexual contexts. Due to the inherently ambiguous nature of disgust elicitors associated with sex, it may be confounding to use such stimuli in attempts to reliably produce a disgust response. As such, this present study will avoid use of this particular subset of disgust elicitors entirely.

Mold and Other Edibles

Moving on, the matter of food aversions is of particular interest considering its mixed relationship with disgust and its elicitors. Angyal, in his dissertation on food aversions, uses meat as a means of commentary on the subject. "Meat", he argues, is a name used specifically to refer to parts of dead animals meant for consumption. Yet, taking into consideration the previously mentioned standards for disgust, dead animals fit the category well due to their pungent smell, fleshy texture, and, of course, potentiality as a disease carrier (Angyal, 1941, p408). The caveat, in this case, is its capacity as a source of nutrients and nourishment. Meat is an extremely prevalent and relied-upon source of protein and fat, both of which are necessary for energy and survival. But, in order for it to lose its disgusting characteristic, the meat must be cleansed or purified by way of cooking or curing. This not only protects against infection or disease but also eliminates the raw and bloody sensory information that contributes to the disgusting quality of raw meat (Angyal, 1941, p409). Regarding the sensory input presented by decayed food, a potentiality for disgust is clear. Over the course of our lives, we come to learn what foods are supposed to feel, smell, look, and taste like. Take apples for another example; when ripe, they are rather firm and come in a variety of vibrant reds, yellows, and greens. Their flesh is crisp and sweet, a taste and texture that is very palatable to the tongue. Yet if given time, the apple deteriorates: its flesh decays, becoming soft and malleable while the apple's skin loses vibrancy and color. The once crisp fruit turns mushy and its sweetness turns sour, now falling harsh on the tongue. It becomes a departure from what we constitute as a 'healthy' apple as the textural, palatableness, and visual changes arise and nausea takes the place of appetite.

Figure 1

A rotten apple

(Haberkamp et al., 2017). DIsgust-RelaTed-Images Database. 1019_food.

Given the right conditions, a new signifier of spoilage will become visible—mold (see Figure 1). In the discussion of food-related disgust, mold must be acknowledged as the predominant elicitor. It acts as a warning sign of spoilage, that a consumable has reached its point of expiration and thus poses a threat as a potential contaminant and source of potential maladies. Yet, above all, it is the physical characteristics of mold that enable its use in image-based disgust testing (Armstrong et al., 2022; Haberkamp et al., 2017). By characteristics of mold, I am referring to color, form, and texture. Mold can present in a wide array of colors, many of which are particularly bright, creating a vibrancy that serves to easily distinguish the mold from the host its sprouts from. This particular feature mirrors a characteristic found occurring in many prey species: that of bright colors insinuating warning and danger (Poulton, 1890, p159). Examples of this include the black widow spider's red hourglass and the bright red, orange, yellow, and blue skin of poisonous frogs. Similarly, the bright blues and yellows of mold may act in the same manner and warn of potential harm to a consumer. The form of mold is just as widely varying, including fuzz akin to a caterpillar, sponge, and sprouts; such forms often allude to the particular species of fungi. Although the form by itself may not be found to be particularly disgusting, its presence on the host is readily apparent as it often differs majorly from the host's form. This contrast of form creates a dichotomy that is unpleasant to many, a disgust that is only furthered with one's understanding of mold and its implication of spoilage. As for the texture of mold, it is often fuzzy, spongy, or slimy—textures which even the perception thereof elicits disgust reactions (Angyal, 1941). The perceived color, form, and texture of mold are, even individually, optimal in eliciting disgust. Alongside its presence as a universal and reliable indicator of spoilage and potential contamination, these characteristics cement mold as a prime elicitor of disgust and a clear choice for pictorial disgust stimuli commonly utilized in picture-based studies (Armstrong et al., 2022; Fink-Lamotte et al., 2022; Haberkamp et al., 2017).

The Brain and Disgust

Enabled by the increasing intelligence and effectiveness of brain-imaging and measurement technologies, past studies of the disgust response have revealed the significant role of the insula region of the brain (Knowles et al., 2019; Wicker et al., 2003). Preliminary studies using fMRI technology assert insular activity within interoceptive processing and an individual's awareness of their internal body states (Critchley et al., 2004). As seen above, even early explorations of disgust note the prevalence of bodily reactions such as the urge to vomit or reduce sensory exposure to the stimulus. Following this line of thought, Wicker and colleagues (2003) performed practical testing of this theory using fMRI technology to measure the brain-activity of subjects as they were exposed to neutral, pleasant, and disgusting aromas. Both the disgusting and pleasant scents were shown to activate the insular cortex in subjects, however, while the disgusting smell activated the anterior section of the insula, the pleasant smell activated the posterior section. This distinction proposes the anterior section of the insular cortex as a particular brain section specialized for the disgust response. The amygdala was also seen to activate in accordance with the participant being exposed to pleasant or disgusting odors—a particularly interesting find considering the amygdala has been seen to play a primary role in the fear response regulation as well (Adolphs, 2013). This may reflect the frequent co-occurrence of the fear and disgust response, however, Wicker's (2003) finding of a lack of amygdala activation when participants were exposed to faces expressing disgust lends credence to an effect of the type of sensory trigger (scent versus sight) as opposed to an effect of the type of stimuli (disgusting versus fearful).

Further research in this vein should endeavor to compare brain region activations of subjects in their different sensory experiences of disgust and fear.

Current Theories of Disgust

Existing within the current literature today are two distinct theories regarding the temporal processing of disgust. The first is proposed by Carretié et al. in their 2011 study on disgust, fear, and their relation to exogenous attention. They put forth the *biological cost and benefit hypothesis*, positing that disgust is inherently associated with ambiguous potential for advantage or disadvantage (Carretié et al., 2011, p252). The disgusting stimuli have the capacity to be either helpful or harmful. Taking fungi as an example, a particularly weird or gross-looking mushroom may, in fact, be edible or perhaps even medicinal; but, to this same effect, that abnormal mushroom could be poisonous or otherwise harmful. Carrietié argues that this duplicity enables a subject to regard the disgusting stimuli for an extended period of time for the purpose of assessing this helpful/harmful potential. The second theory is put forth by Kelly Knowles and colleagues in their 2019 qualitative review of disgust mechanisms. They back the *functional perspective hypothesis on attentional avoidance of disgust* which purports that people are able and likely to disengage from disgusting stimuli (Knowles et al., 2019, p19). Commonly, they both associate disgusting stimuli with slow or time-independent processing and fearful stimuli with faster processing due to fearful stimuli often indicating more immediate danger. Yet, as deduced, the main distinction between these two schools of thought lies within the behavioral response: Carrietié et al. (2011) predict maintenance of gaze on disgusting stimuli for the purpose of exploration and assessment while Knowles et al. (2019) predict rapid disengagement.

Fear

Fear, like disgust, is a primordial emotion, present and necessary within all life forms competing for survival and the continuation of their species. Although, today, humans are less ruled by instincts and distinguish ourselves from animals through rational thought and language, there are instances in which retained subconscious instincts still take hold and cause reactions that do not coincide or cooperate with our conscious cognitive processes. Fear is one of those elicitors; it presents as an automatic arousal of the sympathetic nervous system, increasing heart rate, causing sweating, and potentially even inducing hyperventilation (Cannon, 1915). In extreme cases, fear can completely shut down the frontal lobe in what Cannon referred to as “fight” or “flight” responses (p187). Following the initial confrontation with fearful stimuli, it has been observed that facial-muscular movements serve to increase sensory intake as a form of self-preservation instinct (Susskind et al., 2008). The eyes of participants presented with fearful stimuli widen and overall eye movement increases while nostrils also flair and air intake is increased. Following this module of action, one either attempts to escape or confront the danger so as to alleviate the potentiality for harm (Cannon, 1915; Foa & Kozak, 1986). If, however, no course of direct approach will resolve the danger, humans will resort to any method of disengagement. As fear-inducing sensory input is what arouses such a reaction, people will try to end sensory engagement by removing themselves from the vicinity. If fleeing the danger proves impossible, secondary means of disengagement take place. This may include the plugging of one's ears as well as the closing or averting of one's eyes. Secondary disengagements will also occur if that is the only action required to quell the sensory input. For example, upon seeing a horror movie jumpscare, one need only look away from the screen to quell the situation.

Ralph Adolphs (2013) breaks fear down into three parts: stimuli, cognition, and behavior. Just as with disgust, fear is moderated by the person's involvement with the fear-elicitor or the 'stimuli' and their control or regulatory ability thereof. Within this study, participants will be tested in a totally controlled laboratory environment where the fearful stimuli are harmless pictures on the screen. Although these fearful stimuli have been selected from the NAPS database as they have been shown to evoke fearful reactions, a fear response to a picture of a predator will differ significantly from a fear response in a physical confrontation with a predator. Adolphs himself notes the wide variation in fear evoking stimuli, saying that fear itself can be evoked through everything from "basic unconditioned stimuli to complex symbolic knowledge" (2013, r84). However, understandably, this variation will also affect the degree and severity of fear response in turn. Notably, numerous laboratory studies investigating the fear response have been performed using simple fear-evoking pictures and have reliably produced results, validating the use of fearful pictorial stimuli (Armstrong et al. 2022; Foa & Kozak, 1986; Lipp & Derakshan, 2005). The cognitive aspect of the fear response procedure revolves around the processing of the fearful image and recognition of its threat. Studies such as those done by Adolphs (2013) and Whalen et al. (2001) illuminate the significant role of the amygdala brain structure in the fear response. However, as will be discussed, such conclusions cannot be considered accurate or complete representations of the brain regions driving cognitive processes of fear. With regard to the present study, this cognition is a main focus and, like disgust, will be measured through the reactive behaviors of the participants, particularly though calculating and comparing the speed at which they avert their gaze from the target fearful stimuli.

Discerning Appropriate Disgust and Fear Stimuli

Discerning stimuli that are appropriate for psychological studies in the case of disgust and fear proved itself difficult due to a prevalent co-occurrence of such emotions (Carretié et al., 2011). Spiders can arouse fear due to their threat of harm through bites and venom as well as disgust due to their severe departure from animals and humans by way of exoskeletons, multiple appendages, mandibles, etc. (Cisler et al., 2009, p12). Taking this complication into account and in an attempt to distinguish the disgusting and fearful stimuli as much as possible, the disgusting stimuli used within this study were drawn from pictures of excreta (or body products) and moldy food as, previously noted, these are prime disgust elicitors and they are not known to arouse fearful reactions, only those of disgust.

Asserted above, the fear response can be triggered by a wide range of elicitors, including stimuli the participant has not necessarily been conditioned to fear. The example of such a fearful stimuli needless of conditioning within Adolphs' essay is the tiger, a commonly known and feared predator. Within the following study, the participants will not be conditioned to fear the particular stimuli they are exposed to through any means. Rather, this study will draw upon the evolutionary fear of predators as they are one of the most prototypical threat stimuli (Adolphs, 2013). Accordingly, pictures of panthers, tigers, dogs, and wolves drawn from the NAPS database of fear inducing images will be used as the fearful stimuli in this study (see Appendix H and I for the database ratings of fearful, disgusting, and neutral stimuli).

Directed Attention

As noted, there are different reactions related to the instinctive disgust and fear responses as they are experienced in daily life. Fearful responses are driven by an increase in sensory input, assumed to improve information gathering and threat assessment to facilitate more appropriate reactions. Disgust responses are driven more so by avoidance behaviors in attempts to avoid contamination or soiling (Angyal, 1941; Susskind et al., 2008). As a result of the different motivators, these two distinct emotional responses have varying initial motor reactions, not only in the nose and mouth as previously mentioned, but in the eyes as well (van Hooff et al., 2013). Furthermore, fear is believed to be a rapid and often automatic process whereas disgust develops slower and is dependent on focal attention. A 2011 study performed by Carretié et al. attempted to uncover the role of exogenous attention, attention that is motivated by the influence of external stimuli, in reaction to disgusting and fearful images. This was accomplished by superimposing distinctly-colored digits over fearful, disgusting, and neutral stimuli and asking participants to, with a key-press, quickly and accurately indicate if the presented digits were both even, both odd, or discordant with one even and one odd digit. They found participants to be significantly slower and less accurate with these responses in the disgusting stimuli trials as compared to the fearful or neutral stimuli trials. The significantly slower response time and greater error rate provides evidence that disgusting stimuli does, in fact, draw and hold our exogenous attention more than fearful images. Hence, they concluded with results opposite of what one might expect if they were to assume, based on Angyal and van Hooff's assertions, that disgusting things elicit greater aversive responses than scary things (1941; 2013).

This has led many psychologists to theorize what may cause greater attraction of exogenous attention in response to disgusting stimuli. Carretié and colleagues (2011), as mentioned above, proposed that the disproportionate and rather unexpected attention dwelling on disgusting images may be a result of exploratory behaviors. Unlike fearful stimuli, which pose immediate potential danger to the observer, disgusting stimuli, especially that of spoiled food products, although contaminating, do not pose the same type of harm. Whereas the spoiled food requires action from the observer to facilitate interaction, a fearful stimuli such as a predator would be able to act on its own accord, relinquishing the human observer from any agency they may have had over the situation and decreasing the likelihood of exploration. Over the last two decades, investigations have been conducted into the relationship between selective attention and fear. One of the most common ways to show this selective attention was through the use of the dot-probe paradigm. Two stimuli, either neutrally or provocatively valenced are presented on the right and left of a screen. Following their presentation, a dot appears in the former position of either the neutral or provocative stimulus. Participants are asked to indicate the side on which the dot appears as fast as they can; their reaction times are recorded. Using pictures of spiders and snakes as their fearful stimuli, Lipp and Derakshan (2005) employed such methodology to test their theories regarding fear and exogenous attention and showed that selective attention is drawn by fearful imagery as their participants were significantly faster in their response times when the dot location was preceded by a fearful image compared to a neutral image. The rationale behind their finding is clear due to the immediate threat posed by threatening, fear-evoking stimuli; attention is drawn immediately to fearful imagery to assess the threat. If the fearful stimuli are found to pose no true bodily threat, attention is directed elsewhere. On the other hand, objects of disgust are, for the most part, inanimate and therefore must be interacted with in order for engagement to occur. As such, the control is in the hands of the viewer and no biological cost is involved in the exploration of repulsive stimuli. This theory was tested in a study spearheaded by Fink-Lamotte (2022) which endeavored to solve the debate over the disgust hypotheses of Knowles et al. (2019) and Carretié et al. (2011) emphasized earlier. Thus, a dot-probe paradigm was employed with disgusting, fearful, and neutral stimuli as the target imagery. With respect to the exposure therapy applications of the disgust and fear response, Fink-Lamotte and colleagues also measured the impact of "contamination fear" on participant's response times. Contamination fear, in this instance, refers to a fear of germs, excreta, and other substances that could contaminate the individual and make them unclean—something commonly seen in OCD. They concluded that subjects, although maintaining focus on disgusting stimuli and exploring them for significantly longer than fearful or neutral stimuli, responded much slower in their dot-probe answers and remembered the details of the disgusting stimuli less accurately. Furthermore, those with higher levels of measured contamination fear dwelled on disgusting stimuli longer than fearful or neutral stimuli. As the dwelling upon disgusting stimuli was significantly longer than either the fear or neutral stimuli, Fink-Lamotte et al. (2022) conclude in support of Carretié's *biological cost and benefit hypothesis* (2011) which, in contrast to Knowles (2019), argued that viewings of disgusting stimuli would be longer, not shorter than other negatively valenced stimuli like fearful imagery. They conclude that this longer viewing time on disgusting stimuli, along with the lower accuracy in remembering the stimuli's details, illustrate the ambiguous nature of the disgust emotion and gross stimuli as a whole. Peculiarly, although this extended dwell time may implicate an exploration of the gross subject, the lack of accurate recall of these stimuli denotes a sort of "cognitive avoidance" that is, as of yet, unexplained (Fink-Lamotte et al., 2022, p1915). Seen within these dot-probe studies, our attention is naturally drawn to disgusting and fearful stimuli, however, it is clear the motivations for each are distinguished. Both stimuli attract attention (over neutral stimuli) as a form of instinctual threat assessment, however, disgusting stimuli, owing to their inherent ambiguity, are allocated more attention in their viewings as the viewer deduces any possible benefit. This period of exploration is what Armstrong and colleagues note to decrease and, eventually, disappear altogether after participants are exposed to the same disgusting stimuli multiple times (2022). The following study centered its focus on this proposed exploratory period and attempted, through the implementation of cognitive load by way of a digit memorization task, to eliminate the theorized cost/benefit analysis period altogether, leaving only the time necessary for basic image content processing.

Cognitive Load

Cognitive load, is, as it sounds, the amount of stress placed on mental operations. Putting such pressures on working memory disrupts many processes of the mind, including but not limited to selective attention and working memory productivity (Lavie et al., 2004; Fitousi & Wenger, 2011). The study done by Lavie and colleagues investigated the effect that a digit memorization task would have on participants' capabilities to succeed in a flanker task. The flanker task, introduced in a 1974 study performed by Eriksen & Erkisen, involves the presentation of a target letter or symbol equally flanked on either side by other letters or symbols. These adjacent letters or symbols, either mirroring or differing from the target, act as 'noise' to disrupt one's capacity to identify the target letter or symbol.

As expected, accuracy and speed of response was dependent on the degree of similarity between the target and noise. The flanker task, thus, requires high selective attention and executive control to perform accurately, making it a perfect way to measure the impact of cognitive load. Lavie et al. (2004) concluded that participants placed under high cognitive load conditions were found to perform significantly worse on the flanker task in both reaction time and accuracy. This insinuates a decrease in focal attention and a seeming inability to ignore distractors. Due to the clear impact of memorization, researchers thus concluded with an inherent link between stress on working memory and cognitive load. Hence, the digit memorization task will be utilized within this study as a means to impart cognitive load on participants. Participants will be organized into 2 groups, a no-cognitive load group that does not receive a digit memorization task and a cognitive load group that receives a 5-digit memorization task before each of the 4 stimuli blocks. Measurements of the time spent in each participant's initial fixation on the disgust, fearful, and neutral stimuli will be taken and compared to one another. I expect to find that the initial dwell time of participants who are under a cognitive load will be significantly shorter than participants not under a cognitive load. Furthermore, in the vein of Carretié et al.'s (2011) findings that asserted disgusting stimuli to attract attention for significantly longer than fearful stimuli, I expect that whereas the results of the no-cognitive load group will still reflect this difference, the cognitive load will serve to equalize the initial dwell times on disgusting and fearful stimuli.

Methods

Participants

The participants in the study (n = 18) were drawn from the Bard College student population, falling between the ages of 18 and 22 years old (mean = 21.1 years old). Participants were recruited through word of mouth. Year distribution included those in year 1 (n=3), year 3 (n=4), and year 4 (n=11) of undergraduate studies at Bard College. Gender distribution includes those identifying as male (n=7), female (n=10), and nonbinary (n=1). Ethnic and racial distributions include those identifying as Latinx (n=6), White (n=10), White/Asian (n=1), and White/Black (n=1) (see Table 1). Participants who reported a need for corrected-to-normal eyesight were instructed to use their contacts or glasses so long as no interruption was found within the eye tracking system's calibration due to the eyewear's employment. Participants were misled to believe that the eye tracking device was actually for measuring their pupil dilation and no mention of eye movements was included so as to retain naïvety during the study. This specific deception is common within eye tracking studies like that performed by Armstrong et al. (2022) that do not employ other measures such as dot-probe tasks which serve to convolute the true measurements of the study. The deception used here was detailed within the study debriefing and participants were given the option to retract their consent after they were made aware of the illusive measures. No participants were dropped in this manner or otherwise. The 18 participants were randomly assigned to one of two groups, cognitive load and no-cognitive load, balanced equally with 9 participants in each group. Aside from ensuring a balanced number of participants in each group, these groups were chosen totally at random.

Figure 2

Demographic Information

Demographic Type		Cognitive Load Group				Full Sample	
		NCL		CL			
		n	%	n	%	n	%
Total		9	50	9	50	18	100
Gender	Male	3	33.33	4	44.44	7	38.89
	Female	6	66.67	4	44.44	10	55.56
	Non-Binary	0	0	1	11.11	1	5.56
Age	18	1	11.11	1	11.11	2	11.11
	19	0	0	1	11.11	1	5.56
	21	2	22.22	3	33.33	5	27.78
	22	6	66.67	4	44.44	10	55.56
Year	1	1	11.11	2	22.22	3	16.67
	3	1	11.11	3	33.33	4	22.22
	4	7	77.78	4	44.44	11	61.11
Ethnicity	Latinx	3	33.33	3	33.33	6	33.33
	White	4	44.44	6	66.67	10	55.56
	White/Asian	1	11.11	0	0	1	5.56
	White/Black	1	11.11	0	0	1	5.56

Apparatus

The device utilized for the eye-tracking of participants was the Tobii Pro Fusion 120Hz Tracker; it was attached beneath the screen of the monitor. The stimuli was presented on a 3024 x 1964 pixel Dell monitor screen with a dedicated lab room within Preston Hall on Bard College's campus. The lab room was isolated so as to reduce potential interruption and contained only a desk, a chair, and the required testing hardware. The dell monitor was connected to a dedicated laptop which powered and ran the Tobii Eye Tracker Manager. The Tobii Pro Fusion 120Hz Tracker does not require perfect head stabilization and, as such, no chin rest was employed. Participants were seated in approximately the same position, each sitting 60cm from the screen. This did, however, leave the measurement techniques more vulnerable to participant interference.

Figure 3

Validation Accuracy and Precision for each Participants Calibration

Load Group	Participant	Validation Accuracy*	Validation Precision**
NCL	1984	0.52°	0.61°
	6402	0.55°	0.45°
	4032	0.67°	0.16°
	3196	0.55°	0.17°
	3218	0.53°	0.38°
	2881	0.5°	0.59°
	6639	0.42°	0.63°
	7666	0.11°	0.47°
	9933	0.9°	0.15°
CL	1504	0.78°	0.2°
	1386	0.78°	0.19°
	1244	0.51°	0.55°
	9702	0.49°	0.16°
	4223	0.72°	0.14°
	7583	0.48°	0.68°
	3043	0.85°	0.34°
	5494	0.56°	0.8°
	8675	0.73°	0.17°

* Validation accuracy is the measure of offset between the actual gaze position and what the eye tracker recorded as the gaze position

** Validation precision is the measure of variation in the recorded data. It is defined as the ability of an eye tracker to reliably reproduce the same gaze point measurement from one sample to the next.

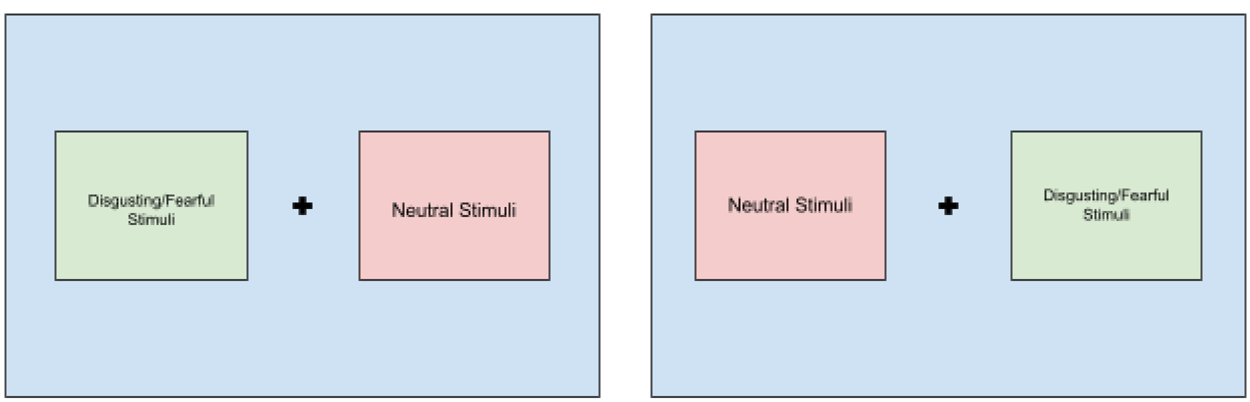
*** The measurements of accuracy and precision were both measured in degrees of visual angle (°). The lower the value, the higher the accuracy and precision.

Stimuli

The stimuli used within the study consisted of disgusting, fearful, and neutral images (see Appendix E for examples). The disgusting and neutral images were retrieved from the Disgust-Related Images (DIRTI) database (Haberkamp et al., 2017). The disgusting stimuli were drawn from the 'body product' and 'food' folders while the neutral stimuli were selected at random from the compilation of every neutral stimuli. The fearful images were retrieved from the Set of Fear Inducing Pictures (SFIP) from the Nencki Affective Picture System provided by the Laboratory of Brain Imaging in the Polish Academy of Sciences, Warsaw, Poland (see Appendix F). The selection, again, was randomized except for a confinement to stimuli tagged as "animal" with the subject material of a canine or feline predator. The fearful and disgusting pictures were always presented adjacent to randomly paired neutral stimuli. These pairings were also randomly selected and were presented twice, counterbalanced to present the disgusting/fearful and neutral stimuli on both the left and right side as seen in Figure 4 below.

Figure 4

Counter-Balanced Stimuli Pair Template



A total of 6 disgusting stimuli (1020 moldy food; 1029 moldy food; 1035 moldy food; 1120 body product; 1130 body product; 1135 body product), 6 fearful stimuli (085 animal; 012 animal; 004 animal; 073 animal; 011 animal; 007 animal), and 12 neutral stimuli (1099 animal neutral; 1049 food neutral; 1042 food neutral; 1141 body product neutral; 1291 hygiene neutral: 1194 injury neutral; 1098 animals neutral; 1097 animals neutral; 1250 death neutral; 1091 animals neutral; 1195 injury/infection neutral; 1193 injury/infection neutral) were used in the study for a total of 12 unique stimuli and 24 overall stimuli when including the mirrored versions (see Appendix G for disgust|neutral and fearful|neutral pairings). The stimuli were scaled to 3 x 2.25 inches on the 3024 x 1964 pixel Dell monitor screen.

Procedure

Participants were greeted and briefed on the study process. They were given an informed consent form to read and sign which noted that the study aimed to evaluate pupil dilation so as to conceal the true eye-tracking measures and eliminate potential participant biases. Following this, they were given a demographic survey to fill out to procure basic information. The participants were then sorted into either the 'cognitive load' or 'no-cognitive load' groups. They were instructed to sit in front of the monitor equipped with the eye-tracking device and were told to situate themselves where their eyes could be picked up by the sensors, approximately 60 cm from the screen. Following that, participants completed the 9-point orientation and calibration and subsequently began the stimulus free-viewing task, instructed simply to keep their eyes on the screen. They were never directed to attend to anything on the screen specifically. The images shown during the free-viewing task were presented at 10-second intervals. This stimuli presentation may seem abnormally long, however, this was put in place to ensure that gaze aversion did, in fact, take place. These stimuli were preceded by a fixation cross presented for 1.5 seconds and succeeded by inter-stimulus intervals of 3 seconds in which the screen was blank. Each participant completed 24 trials separated into 4 blocks of 6 trials (see Appendix G for block groupings and stimuli presentation order). Each block consisted of randomly, equally distributed disgusting-paired and fearful-paired stimuli with the restriction that no image was shown twice within each block. Before each block, participants within the cognitive load group were presented with a string of 5 numbers. These numbers were presented until the participant felt confident in their memorization. The participants, following the end of each block, were then presented with a single number and instructed to indicate if that number appeared in the previously memorized string on a paper sheet in front of them. Participants that failed a memory check were to be excluded from the study, however, no participants were excluded in this manner. Following the free-viewing task, participants were asked to rate each of the disgusting and fearful stimuli on their individual perception of how disgusting (0-100), scary (0-100), and unarousing/arousing (-100-100) the images were. They were then debriefed on the intent of the study, the analyses taking place, and the deceptive measures used to eliminate participant bias as a confounding variable.

Results

Results were garnered from a combination of outputs provided by the Tobii Eye-Tracking software and the manual rating responses provided by each of the participants. The Tobii eye-tracker operates by measuring the location of the target's gaze every 7 milliseconds. By imposing areas of interest (AOI) over the stimuli (one over the fearful or disgusting stimuli and their corresponding neutral stimuli counterparts), the program then records a hit (1) or a miss (0) dependent on the measured gaze location and its placement on each respective AOI. The program also provides a distinction of the associated 'gaze event' (fixation or saccade) that defines the eyes behavior at the time of measurement. A fixation is the focusing and resting of one's gaze upon a point or area within the visual field (the AOI in this case) for exploration and processing. A saccade is defined as movement of the eyes, and, along with an inability of the hardware to locate the eyes, or the placement of the eyes in an onscreen area that is unclassified by an AOI, would cause the program to register a miss (0). In the instance that the eyes could not be found, this may have been caused by participants' gaze leaving the screen (akin to the cause of an "unclassified" miss) or, in some cases, eye-tracking may have been blocked by eyewear such as glasses or contacts. As the eye tracker measured in intervals of 7ms, gaze events marked to be fixations could be as low as 7 ms. However, taking into consideration the Potter et al. (2014) conclusion that found participants capable of processing images at a minimum of 13 ms, for the purposes of this study, only fixation gaze events with a minimum of two consecutive hits, or 14 ms, were considered true fixations. This is the closest measurement to 13 ms as allowed by the constraints of the Tobii program. A saccadic gaze event that occurred for more than 6 hits, or 42 milliseconds, and did not return to a fixation gaze event on the same AOI it left from counted as the end of a true fixation. In this same vein, 2 misses, classified as either "eyes not found" or "unclassified", for a total of 14 milliseconds or longer was considered the end of a true fixation as well. These 14 and 42 millisecond cutoffs were chosen, again, in relation to the Potter et al. (2014) study. This study evaluated the speed at which participants were able to process information using a rapid serial visual presentation (RSVP) task with a series of 6 to 12 pictures presented at 13-80 ms intervals without breaks between stimuli. Before each stimuli set, participants were presented with a worded description of the stimuli they should look for. Following each stimuli presentation, participants were asked to answer "yes" if they identified the target in the set or "no" if they did not. As noted, participants were able to identify targets presented as quickly as 13 milliseconds (Potter et al., 2014, p18). With respect to the saccade exclusionary criteria, the 42 millisecond cutoff used in the present study was calculated by summing the previously established minimum requirements for a fixation off of the target AOI: a 14 ms saccade away from the target AOI, a 14 millisecond fixation elsewhere, and then a final 14 millisecond saccade return. Any saccade that lasted fewer than 42 milliseconds (6 misses) and returned to the target AOI was not considered as a break in fixation. Dwell time on stimuli was calculated by manually summing the number of hits/misses that constituted the fixation according to the criteria noted above and then multiplying the sum by 7. This product reflected the millisecond duration of the primary dwelling calculated for each stimuli each participant was exposed to. An alpha level of .05 was used for all statistical tests.

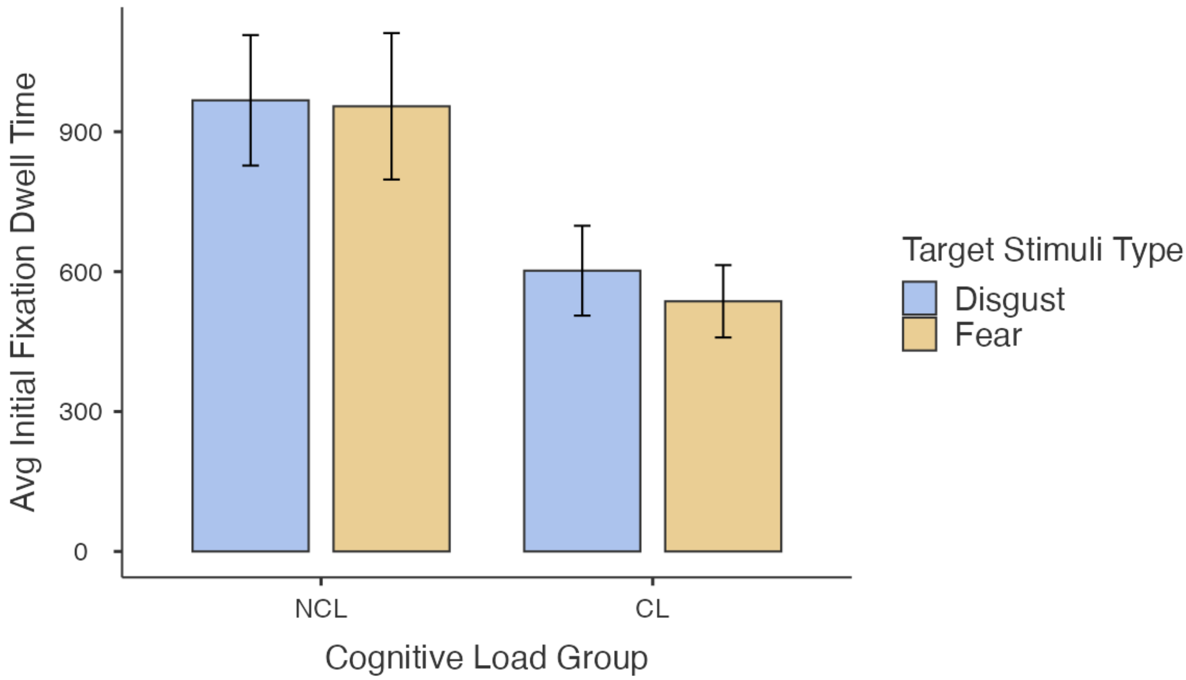
Dwell Time

To test for significant impact of cognitive load in each group, a 2 Load Group (no-cognitive load, cognitive load) X 2 Stimuli Type (disgusting, fearful) ANOVA was conducted on mean initial dwell times. The 2X2 ANOVA (see Figure 5) revealed a main effect of Load Group such that initial dwellings of participants in the no-cognitive load group were significantly longer than those in the cognitive load group, $F(1, 34) = 10.3109$, $p = 0.003$. However, no main effect of Stimuli Type was found, suggesting that cognitive load has a similarly reducing effect with regard to both types of stimuli, $F(1, 34) = 0.1034$, $p = 0.79$. Also, no significant interaction was found between the two factors, $F(1, 34) = 0.0469$, $p = 0.83$. In summary, participants subjected to a cognitive load during stimuli viewing were significantly quicker to avert their gaze from the initial fixation when looking at both fearful and disgusting stimuli. Within the disgusting stimuli used, an independent sample t-test revealed no significant difference was found between the initial dwell times on bodily product images compared to spoiled food images ($p > .05$). Furthermore, no significant differences were found between the primary dwell times of bodily products and neutral images ($p > .05$) as well as between spoiled food and neutral images ($p > .05$). This departs from Armstrong et al.'s finding that the food images held participants' gaze more than the neutral images (Armstrong et al., 2022). In the case of the fearful stimuli, another t-test was run which concluded with no significant difference between the initial dwell time on fearful stimuli and the adjacently-presented neutral stimuli ($p > .05$).

One participant within the no-cognitive load group stood out with longer initial dwell times in response to both fearful and disgusting stimuli. Their average initial dwell time on disgusting stimuli was over 1 *SD* longer than the mean whereas their average initial dwell time on fearful stimuli was over 2 *SD* longer than the mean. Accordingly, another 2 Load Group (no-cognitive load, cognitive load) X 2 Stimuli Type (disgusting, fearful) ANOVA excluding this participant's results. However, this concluded with similar significance: a main effect of cognitive load group was found, $F(1, 32) = 7.84$, $p = .009$, no main effect of stimuli type was found, $F(1, 32) = 0.46$, $p = 0.5$, and no significant interaction was found between the two effects, $F(1, 32) = .0045$, $p = 0.95$.

Figure 5

Load Group x Average Initial Dwell Time on Disgusting or Fearful Stimuli Categorized by Stimuli Type

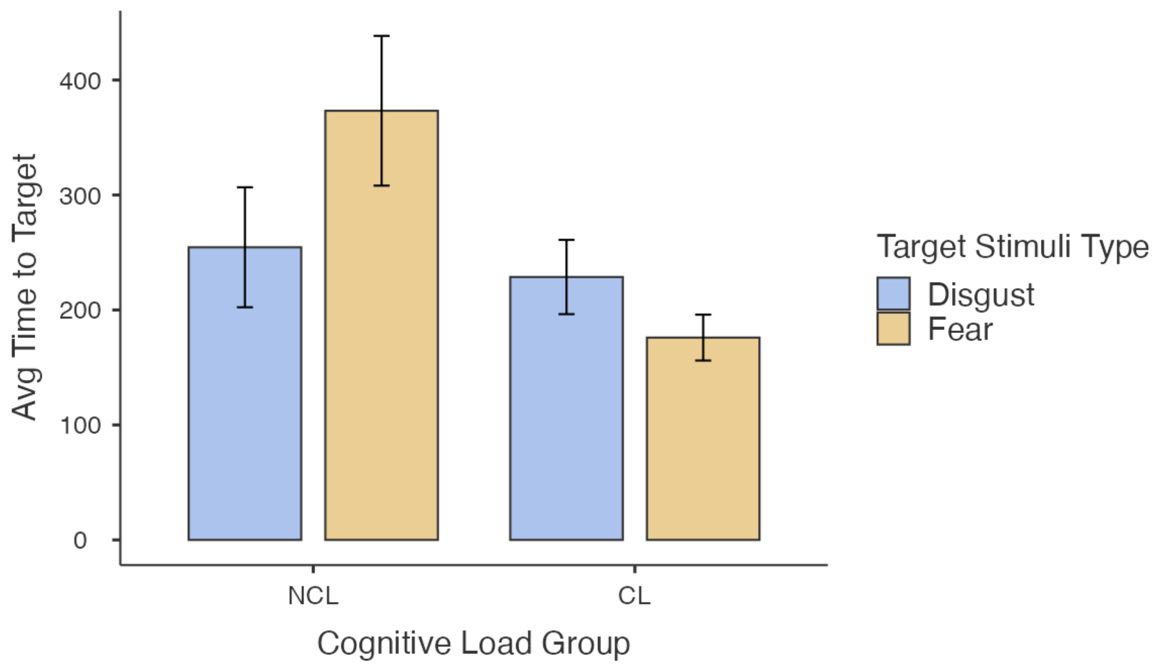


Time to Target

Another 2x2 ANOVA evaluating Load Group (no-cognitive load and cognitive load) against Target Stimuli Type (disgusting and fearful) was completed (see Figure 6). However, this time, the analysis was done with regard to the time it took for participants to begin their first fixation on the target disgusting or fearful stimuli. A significant main effect of Load Group was found, alluding to a significant difference in time taken to fixate on target between those who received a cognitive load and those who did not, $F(1, 34) = 5.924$, $p = 0.021$. Although the main effect of this was significant, the main effect of Stimuli Type (disgusting or fearful) was not, showing that the type of emotionally-charged stimuli did not have a significant effect on the time taken by each participant to fixate on the fearful or disgusting stimuli, $F(1, 34) = 0.519$, $p = 0.477$. The interaction between these two main effects, although not found to be significant, is shown to approach significance, $F(1, 34) = 3.496$, $p = 0.071$.

Figure 6

Target Stimuli Type x Average Time to Fixate on Target Stimuli Categorized by Load Group



T-tests comparing the average time to target grouped by cognitive load group reveal a significant difference in time to target averages between cognitive load groups when regarding fearful stimuli ($p = .011$), but not when regarding disgusting stimuli ($p = 0.679$). As illustrated by the graph above, a cognitive load seemingly quickens the speed at which participants fixate on the fearful stimuli. This result alludes to a potential increase in subconscious predator threat awareness as a result of conscious processes being occupied.

Fixating on Neutral or Disgusting/Fearful Stimuli First

Throughout the multitude of trials run on the participants, it was observed that their gaze was not always immediately drawn to the emotionally relevant stimuli (disgusting or fearful). Rather, many times, their attention was drawn towards and rested on the neutral stimuli before ever moving to the disgusting or fearful. Although one may expect attention to always be drawn to emotionally relevant stimuli, especially a threatening stimuli such as a predator or contaminant (like excreta), the controlled laboratory setting and digitized stimuli presentation facilitate an environment in which such reactions may not reflect real-world reactions. With regard to cognitive load, participants that did not receive a cognitive load regarded the disgust images first 53.7% of the time (neutral first 46.3% of the time) and fearful images first 47.22% of the time (neutral first 52.78% of the time). Overall, those in the NCL group fixated on disgusting or fearful stimuli first 50.46% of the time (neutral 49.54%). Those that did receive a cognitive load regarded disgusting and fearful images first 51.85% of the time (neutral 48.15%). There was no significant deviation from 50/50 chance as to what type of image participants fixated on first between disgusting, fearful, and neutral images and regardless of cognitive load group. This means that attention was drawn to all three image types equally. Emotionally evocative images are noted to draw attention (Carretié et al., 2011), however, the fact that the emotional images utilized in this study drew attention similarly to the neutral stimuli may, again, result from the controlled laboratory setting. Other explanations for such a departure from the expected attractive nature of emotional stimuli may lie in participants' peripheral vision or in participants becoming accustomed to the set up of the stimuli presentations.

Image Ratings

Following the completion of the free-viewing task, participants were presented with a slideshow of each disgusting and fearful stimuli as shown within the free-viewing task. Participants were then asked to rate each image, regardless of its predetermined disgust or fearful identification, on scales of disgust, fear, and pleasantness (see Figure 7). The scales utilized for disgust and fear were 0 to 100 while the pleasantness scale was -100 to 100. The -100 to 100 scale was used to account for the possibility that participants may perceive some stimuli to be pleasant or unpleasant, reflected accordingly with either positive numeric ratings or negative numeric ratings. Participants were also given a scale taken from Armstrong et al.'s (2022) study that denoted numeric rating with an associated adverb (see Appendix J). It was expected that the ratings of the disgusting stimuli were going to mirror the results of Armstrong et al.'s (2022) study, reporting that bodily product images were found to be more disgusting than spoiled food images. However, a t-test revealed that our sample showed no significant difference in the disgust ratings ($p = 0.376$) between the spoiled food image and the bodily product images. Furthermore, Armstrong and colleagues also found that the excreta images they employed will be reported to elicit more fear than images of spoiled food, potentially as a result of the increased danger of contamination by bodily products as opposed to contamination by spoiled food. However, the results from our sample showed, once more, a deviation from Armstrong in a lack of significant difference between the fear ratings for body product images and moldy food images ($p = 0.49$). No significant difference was found in pleasantness ratings between moldy food and body products either ($p = 0.35$).

Figure 7

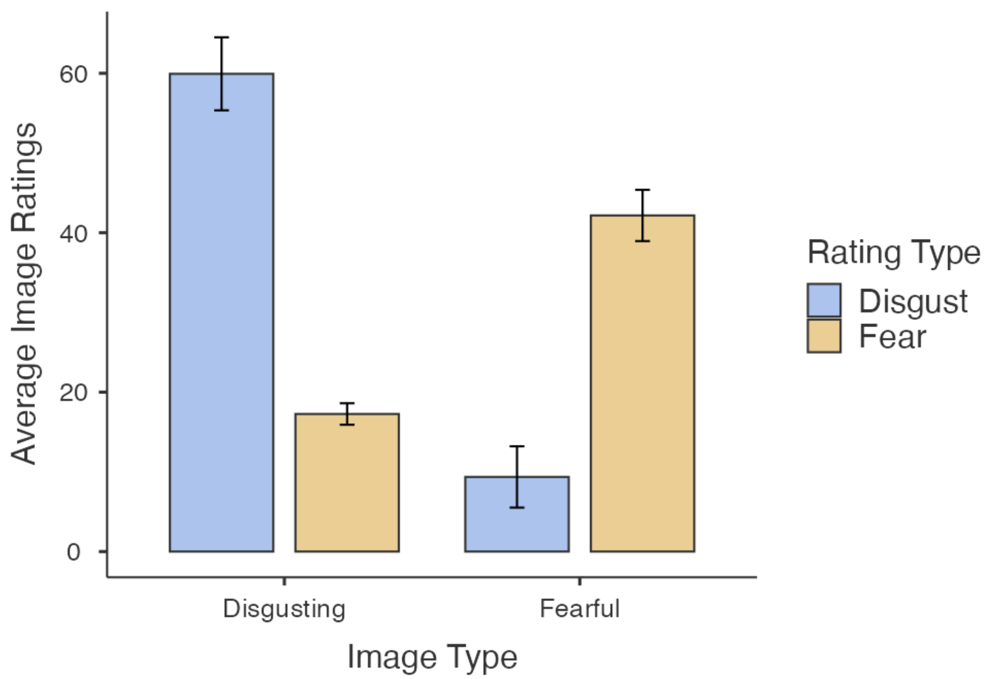
Average Participant Disgust, Fear, and Pleasantness Ratings for Each Disgusting (Food and Body Products) and Fearful Stimuli (Animals)

Image Database (Image Type)	Stimuli	Rating Type		
		Disgust Rating	Fear Rating	Pleasant Rating
DIRTI Database (Disgusting)	Moldy Crabapples	51.39	12.28	-40.22
	Moldy Cream Cheese	53	16.89	-39.94
	Moldy Banana	61.72	19.39	-50.28
	Vomit on Sidewalk	75.17	20.5	-69.72
	Bloody Sink	47.5	19.94	-33.11
	Snot in Tissue	70.83	14.56	-65.94
Means		59.935	17.26	-49.87
NAPS Database (Fearful)	Tiger	0.56	38.11	27.61
	Fighting Dogs	4.89	44.17	-15.17
	Snarling Wolf	5.17	40.17	12
	Taxidermy Lion	17.56	43.11	-26.28
	Black Panther	3.56	31.89	21.22
	Wolf over Prey	24.44	55.56	-20.28
Means		9.36	42.17	-0.15

A 2 Image Type (disgusting and fearful) x 2 Rating Type (disgust and fear) ANOVA was run to determine the effectiveness of the stimuli employed from the DIRTI and NAPS databases (see Figure 8). The main effect of Rating Type was not found to be significant, $F(1, 23) = 2.03$, $p = 0.169$. The main effect of Image Type, however, was found to be significant, $F(1, 23) = 13.74$, $p = .001$. The significance of this main effect of image type reflects a confirmation that the emotionally-evocative pictorial stimuli employed were successful in evoking their respective emotions of fear and disgust. This is further confirmed by an extremely significant interaction effect between the Image Type and Rating Type, $F(1, 23) = 118.86$, $p < .001$. This result confirms that the disgusting images were found to be gross, but not scary while the fearful images were found to be scary but not gross. This validates the employment of the specific images taken from the DIRTI and NAPS database for this study.

Figure 8

Average Disgust and Fear Ratings for the Disgusting and Fearful Stimuli Employed



Discussion

The intention of this study was to garner a better grasp of the cognitive processes at play within the behavioral response to disgusting stimuli. This evaluation was performed in contrast to the fear response, an emotional phenomena that is similar to and often coincident with disgust. Both emotions have long been viewed as comparable in their elicitors and aversively-natured reactions (Knowles et al., 2018; Adolphs, 2013). More recently, however, discourse on this subject has attempted to distinguish disgust from fear, a rather successful endeavor as many, such as Armstrong et al. (2022) and Lipp & Derakshan, (2005), have been reliably finding significant differences in aspects like eye-movement. Aforementioned brain-imaging research such as Wicker et al. (2003) and Whalen et al. (2001) showed differing brain activation patterns for disgust and fear as well. The current and cited studies serve not only to differentiate these emotions, but to further uncover the functions essential in driving the expression of and reaction to disgust and fear. Whereas Armstrong et al.'s (2022) study focused on the impact and effect of prolonged exposure on avoidant-gaze behavior in regard to disgusting and fearful stimuli, this study aimed to evaluate the avoidant-gaze mechanisms at play within participant's first focusing of gaze on the elicitors. Thus, this study heavily leans on the purported exploratory phase explanation given for the extended dwelling of attention on disgusting stimuli. Noted earlier, there are two schools of thought regarding disgust, yet it is only from within Carretié et al.'s (2011) arguments that the theorized cost/benefit analysis phase is derived. Analyses of this study's results provide evidence supporting the *biological cost and benefit hypothesis* and the presence of an initial extended exploratory phase present within the disgust response: the initial fixation times on disgusting stimuli of participants under a cognitive load were significantly shorter than the initial fixations of those not burdened by a cognitive load. Notably, though, the imparting of a cognitive load on participants significantly reduced the initial dwell time of participants viewing fearful images as well. The current fear literature does not surmise an exploratory phase similar to the one proposed by the *biological cost and benefit hypothesis* for disgust. However, the similar impact of cognitive load on fearful stimuli does insinuate the suppression of a yet undefined cognitive process within the fear response. Nonetheless, these results confirm that the capacity of one's working memory, their ability to manage with a cognitive load, is a significant driving resource behind both the fear and disgust responses' preliminary evaluation period. Understanding the part played by working memory within disgust and fearful responses can provide new insights into the still obscure nature of these reactions and the methodology of the therapeutic efforts targeting phobias and related anxiety disorders.

Within this vein, the research has had immense focus on obsessive compulsive disorder. Acknowledged by Kelly Knowles and colleagues in their 2019 study, many of the recent investigations into potential linkages between anxiety, OCD, and disgust have narrowed focus to symptoms and brain regions. One such example is the 2017 study performed by Heather Berlin and colleagues that investigated insular cortex activity in those with obsessive-compulsive disorder. They performed a similar test to the Wicker et al. (2003) study of the olfactory response to disgust, again using fMRI technology to compare brain activity between participants with OCD and healthy participants. Validating these results, Berlin et al. (2017) found, once more, that the insula section was activated in response to both the pleasant and unpleasant odors. Yet, strikingly, they found that unpleasant odors activated a small portion of the left anterior section of the insula significantly more in participants with

OCD diagnoses than healthy participants as compared to their responses to the pleasant and neutral odors. Notable as well, they found that the participants clinically diagnosed with OCD reported significantly higher frequency of disgust experiences than healthy participants as well as an approach towards a significantly higher disgust sensitivity than healthy participants. From these measures, they deduced a positive correlation between reported disgust sensitivity and left anterior insula activation to unpleasant odors as compared to pleasant or neutral odors. This precision work provides a distinct target within the brain, not only for researchers of disgust, but for OCD treatment research as well. On the other hand, though, the brain systems at play within fear and disgust remain ambiguous as psychologists realize, more than ever, that structures like the amygdala and insular cortex are not so much the sole perpetrators of such emotional responses that they were thought to be. Rather evidence directs researchers towards “network-based views” that regard these brain structures as pieces of an ensemble (Adolphs, 2013, R84). Although this turn in approach does not negate the multitude of research that focuses solely on the amygdala or the insular cortex, it does illuminate these studies as scratches on the surface rather than an encompassing of the biological drivers behind emotions like fear and disgust as a whole. Adding to the hurdles of such research and development of comprehension, as much light as studies like Berlin et al. (2017) may shed upon disgust’s relation with OCD, these studies look at disgust proneness and disorder symptoms concurrently, thus disabling any establishment of a causal connection between proneness to disgust and OCD and anxiety (Knowles et al., 2019, p9). Further exploration of the role of the insula within sensory-fueled responses is necessary, especially when one considers the ambiguity of its activation in response to both pleasant and unpleasant stimuli (Berlin et al., 2017; Wicker et al., 2003). Lack of causal linkage aside, understanding the role of such core brain regions involved in the fear and disgust response facilitates the creation of better strategies, technologies, and medicines to aid in coping with associated mental health struggles.

With regard to the present study, future iterations may also benefit from the employment of similar brain imaging techniques used within aforementioned studies. Such technology as fMRI would enable researchers to analyze brain activity in its active response to disgusting and fearful stimuli while the participant is simultaneously under a cognitive load. These techniques could then be applied to further medicinal research that targets particular brain regions like the amygdala or insular cortex for novel treatment methods. Due to the nature of obsessive-compulsive disorder, much of the anxiety response occurs out of sentiments of contamination (Rachman, 2004). Approximately half of those who are clinically diagnosed with OCD suffer from contamination-based fears such as dirt and disease obsessions or a compulsory need for cleanliness. Rachman (2004) also notes that this soiling can take the form of a sort of 'mental contamination' as well as a 'physical contamination' (p1228). This dichotomy lends to the difficult lives led by those coping with OCD—even after one may have washed their hands ten times, the 'mental contamination' may remain and therefore force the individual to continue the cleaning ritual in an attempt to abate the compulsion. This concept of contamination is yet another bridge that links OCD to disgust. Asserted above, Andres Angyal (1941) posits the fear of contamination as the main driving force behind the human disgust reaction. In this instance, Angyal is speaking of a 'healthy' person's experience of disgust, yet the parallel of driving force behind disgust and the compulsions of those with OCD should not be overlooked. Providing further support for such a connection between the disgust response and anxiety disorders, techniques such as exposure therapy illuminate that past researchers have also recognized the overlap of the disgust response and

OCD and phobic tendencies and have subsequently adapted their approach accordingly. However, as observed by Rachman, “The fears of contamination are challenging because the current treatment, exposure and response prevention, can reduce the fear but it is demanding and many patients find it exhausting,” (2004, p1228). Such exhaustion would place heavy strain on the attrition of patients and make continuous and sustained therapy difficult. As such, it is imperative that we continue to develop treatment methods for such impactful disorders, both in a therapeutic and medicinal manner.

This study uncovered significant results regarding the impact cognitive load has on people's ability to cope with and process disgusting and fearful images. Although it may be too early to comment on the structured application of such findings, preliminary applications are apparent. Grounding techniques are very common in the treatment of anxiety disorders like OCD and serve not only to reorient the person to their surroundings, but also to distract the person suffering from an anxiety attack. In this way, these techniques act as a cognitive load inherently, potentially working to suppress and alleviate the acute stress. Further iterations of these grounding techniques may endeavor to impart a more intense cognitive load as, seen within this study, the impact of a cognitive load severely suppresses the response to such emotionally evocative images. Though, again, notably, this study takes place in highly controlled laboratory conditions and with a rather small, neurotypical sample. Future studies should gather participants from a larger and more diverse sample size and attempt to increase the generalizability of the results. This could be done in a variety of ways, including, of course, presentation of authentic disgusting and fearful stimuli to participants. Inanimate objects like moldy food and excreta would be easy to manage, and past studies have used spiders and snakes as their fear elicitors which may prove effective and manageable in small containers (Lipp & Derakshan, 2005).

However, testing fear response to real predatory animals may be needlessly difficult and dangerous for both researchers and participants. Furthermore, the use of unpredictable variables like live animals creates confounds within the research as each participant's interaction may differ depending on the uncontrolled behavior of the animal. Turning from this, then, future versions may look to modern advances such as virtual- or altered-reality technology to simulate more believable disgusting and fearful stimuli within more controllable and safe settings. The options offered by altered- and virtual-reality open endless avenues for research into these emotional responses as each gross or scary experience can be curtailed with precise details. This limitless capability pairs well with the multitude of disgust and fear elicitors as such technology enables research into the wide variety of aversive reactions both in the distinction and coincident thereof. Furthermore, these technologies would enable dynamic movement within the stimuli. Important within the discussion of disgust and fear is the agency of the observer. Within the real world, elicitors of fear, like predators, often act of their own accord, regardless of the actions or desires of the observer, while disgust elicitors, like vomit and mold, are inanimate and dependent on action from the observer. Within the setting of a study such as the one present that uses pictorial elicitors, the choice of engagement lay solely in the hands of the observer. As such, the reactions of the participants, specifically their reactions to fearful stimuli, are not influenced by this lack of agency that is typical in a real world situation. By introducing unpredictability into fearful elicitors through animated movement, researchers would be able to present participants with increasingly realistic threats. Such evolved approaches may attempt to incorporate methods such as those seen within studies like Wicker et al. (2003) which involved the use of unpleasant odors as elicitors of disgust. With regard to the fearful stimuli, if predatory animals are utilized again, the associated scent could be of the animal's musk or the animal's typical habitat. The combination of disgusting and fearful imagery with corresponding smells alongside the introduction of dynamic movement may prove extremely effective in increasing the realism of the emotional experience and eliciting a more accurate and authentic disgust or fearful response from the subject.

This same application of virtual reality combined with smell can be utilized in exposure therapies that center around decreasing sensitivity to contaminating stimuli. A more effective therapeutic method may reduce the overall treatment time and provide some alleviation to the extremely low attrition within exposure therapies. The capability for control and manipulation afforded to the therapist designing the virtual reality experience also enables a tailoring of the exposure that can target a specific patient's particular affliction. Applying the results of this study, such therapeutic methods may also shift to emphasize occupation of the working memory through an externally- or self-imposed cognitive load. This study imparted the load preemptively, but future studies may test the effectiveness when the load is imparted subsequent to the exposures. A cognitive load in either capacity could serve to reduce the salience of the acute stress reactions experienced in anxiety and OCD and subsequently increase the quality of life of those diagnosed with such disorders. However, the implications of this study extend beyond those with a diagnosis. Disgust and fear are universal and unavoidable in a world as terrifying, gross, and unpredictable as ours and, accordingly, the way we understand, interact with, and react to such elicitors remains relevant to everyone, neurodivergent or otherwise. Advancing our comprehension of such processes provides insight into the function of our brain and our behaviors, both crucial aspects in garnering an overarching grasp of humanity and our interactions with our environment.

Appendix A - IRB Letter of Approval

Bard College Institutional Review Board

Date: 2/5/2023
To: Asa Kaplan
Cc: Thomas Hutcheon; Nazir Nazari
From: Ziad M. Abu-Rish, IRB Chair
Re: Exploration of Disgust: the Cognitive Resources Necessary for Disgust Resilience

DECISION: APPROVED

Dear Asa Kaplan:

The Bard IRB committee has reviewed your revised proposal. Your proposal is approved through February 5, 2024. Your case number is 2023FEB5-KAP.

Please notify the IRB if your methodology changes or unexpected events arise.

We wish you the best of luck with your research.

Ziad M. Abu-Rish, Ph.D.
IRB Chair
Associate Professor of Human Rights and Middle Eastern Studies
Bard College
zaburish@bard.edu

Email: irb@bard.edu | Website: https://www.bard.edu/irb | Phone: 845-758-6822
PO Box 5000, Annandale-on-Hudson, New York 12504-5000

Appendix B - Informed Consent

Primary Investigator: Asa Kaplan
Faculty Advisor: Tom Hutcheon (thutcheo@bard.edu) Psychology Program
Bard College

Project Title
Exploration of Disgust: the Cognitive Resources Necessary for Disgust Resilience

Introduction
You are being asked to be a volunteer in an experiment conducted by Asa Kaplan for his Senior Project in Psychology. Please read the following information carefully prior to proceeding to the experiment.

Purpose
The purpose of this experiment is to better understand the factors that influence eye behaviors and pupil dilation in response to disgusting and fearful stimuli. The exploration into behavioral responses to differently active pictorial stimuli has been a common topic of analysis in many psychology studies. The current study attempts to expand upon a recent study evaluating these behavioral responses in the presence of fearful and disgusting stimuli.

Study Procedure
If you decide to participate, you will be asked to complete a questionnaire that provides us with basic demographic information including your age, race, and gender. Following that, you will be presented with a varying-length digit string which you will be asked to memorize. Afterwards, you will proceed through 4 blocks of 6 stimuli sets for a total of 24 stimuli sets. No responses to these sets will be recorded. Your pupil dilation will be measured in response to these pictorial stimuli sets. The pictures used are those considered to be scary and gross such as human fecal matter for disgusting imagery and a feral bear for fearful imagery. The pupil dilation measures will be used to evaluate the cognitive strain placed upon you as you regard these images. Following your participation, you will be provided with information about the specific hypothesis in this study. The duration of your participation, including the submission of the demographic survey, the core study, and the debrief process will take a maximum of 35 minutes. Participation in this study is completely voluntary and you are free to stop at any time without penalty.

Risks and Discomforts

As you will be tasked with looking at disgusting and fearful images people may find disturbing, discomfort is to be expected within the study. Once more, you are free to stop the experiment at any time without penalty.

Benefits

You are not likely to benefit directly from participating in this study. However, what we learn from this experiment will contribute to what we know about the cognitive mechanisms that are at play within image recognition

Compensation

You will be entered into a raffle for the chance to win a 50$ gift card.

Exclusion/Inclusion Criteria

Individuals must be over the age of 18 to participate in this study.

Confidentiality

Once you have completed the experiment, your data will be automatically assigned a participant ID code. There will be no way to directly link your name with your data. In addition, study data will be kept on password-protected folders and only study personnel will have access to these files. No personally identifying information will be collected electronically or appear when the results of the study are presented or published. If you would like to view the completed senior project, it will be made available in the Bard College Library and published on Bard Digital Commons.

Questions

If you have any questions about your rights as a research participant, you may contact the Principal Investigator, Asa Kaplan at ak5082@bard.edu, the project advisor Tom Hutcheon at thutcheo@bard.edu, or the chair of the Bard College institutional review board at irb@bard.edu.

By signing, you arm that you have read and understood the content of the consent form and understand that you will be exposed to gross and scary imagery over the course of this study.

X____

Appendix C - Demographics Survey

Please indicate your age: __

Please indicate your gender

- ☐ Male
- ☐ Female
- ☐ Non-Binary
- ☐ Gender-fluid
- ☐ Other: _________

Please indicate your current year at Bard College:

- ☐ First year
- ☐ Second year
- ☐ Third year
- ☐ Fourth year
- ☐ Fifth year

Please indicate your ethnicity(ies):

- ☐ White
- ☐ Asian
- ☐ Black or African-American
- ☐ Alaskan Native or Native American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Latinx or Hispanic
- ☐ Middle-Eastern
- ☐ Other: _________

Appendix D - Study Debriefing

This study is concerned with the evaluation of gaze behaviors in response to disgusting and fearful stimuli. Previous studies have found that people linger their gaze on disgusting stimuli longer than they do on fearful stimuli and many theories have been put forth as to what causes this disparity. A theory that has gained much traction asserts that this initial lingering gaze upon disgusting stimuli is a moment of investigation. A recent study performed by Armstrong and colleagues found that repeated and prolonged exposure to disgusting stimuli leads to a marked increase in gaze aversion, supporting this theory of preliminary evaluation. Once this evaluation is completed initially, the dwell time reduces until becoming nonexistent during subsequent exposures to the same image.

How was this tested?
In this study, you were asked to perform two tasks—a digit memorization task and a stimulus viewing task. All participants performed these tasks, each going through 6 blocks of 10 trials. 2 blocks were preceded by no digit memorization, 2 blocks were preceded by a 2-digit memorization task, and the final two blocks were preceded by a 5-digit memorization task. These differences emulated either a high cognitive strain, a low cognitive strain, or a lack thereof. Following the 6 blocks of this task, all participants were then asked to rate each stimuli image in terms of their arousal, pleasantness, fearfulness, and disgustingness.

Hypotheses and main questions:
We expect to find that as cognitive load on subjects increases, the initial dwell time on disgusting images will reduce accordingly and align more with gaze behavior in response to fearful stimuli. Namely, in trials where there is no digit memorization task, we predict longer initial gaze and exploration of disgusting stimuli; in trials with a 5-digit memorization task, however, we expect a significantly shorter dwell time on disgusting stimuli.

Why is this important to study?
The distinction between disgust and fear is a rather novel undertaking that has only come to light recently within the psychological world. In the past, responses to fear and disgust were often lumped together, however, recent investigations have provided a myriad of physiological differences between the two in heart rate and eye-movement just to name two. Psychological evaluation on these two instinct-driven emotions may provide insight into the “lizard brain” of humans, namely the part of the brain still driven by instincts as opposed to cognitive, rational thought.

What was the role of the deception?

At the beginning of the study, participants were told their pupil dilation would be measured as the eye-tracking programs were not working. This, in fact, was a deceptive measure taken to ensure that participants would not attempt to alter their natural eye movements and maintain the validity of the study. Eye-movement measurements were taken.

What if I want to know more?

If you are interested in learning more about gaze behavior in response to disgust or fearful stimuli, direct yourself towards:

Armstrong, T., Stewart, J. G., Dalmaijer, E. S., Rowe, M., Danielson, S., Engel, M., Bailey, B., & Morris, M. (2020). I've seen enough! Prolonged and repeated exposure to disgusting stimuli increases oculomotor avoidance. Emotion. https://doi.org/10.1037/emo0000919.

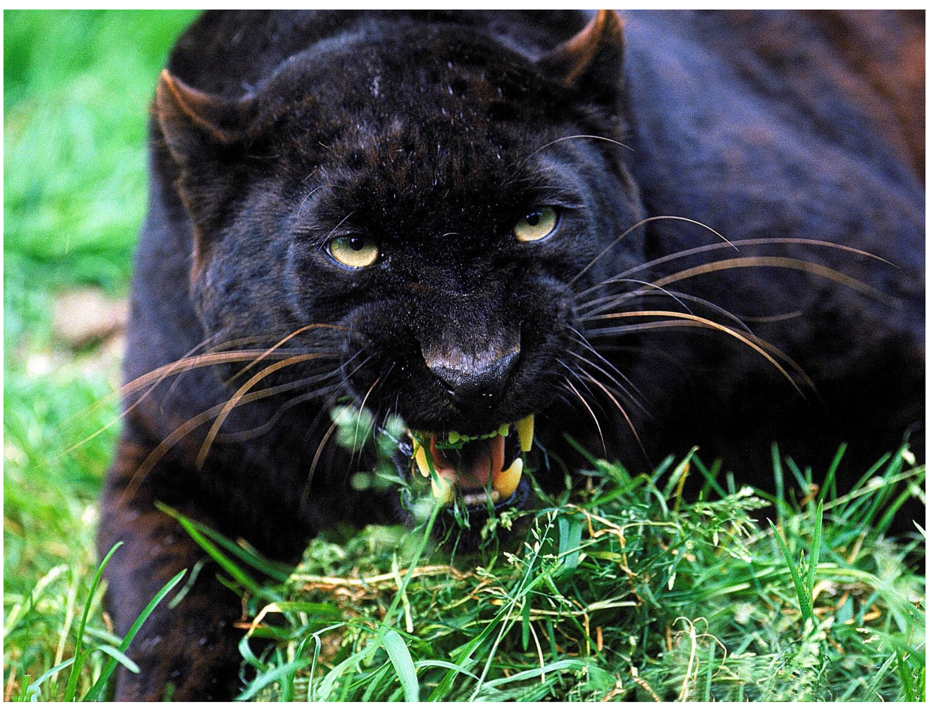
If you would like to receive a report of this research when it is completed (or a summary of the findings), please contact Asa Kaplan at ak5082@bard.edu.

If you have concerns about your rights as a participant in this experiment, please contact the Bard IRB Chair at zaburish@bard.edu or the IRB board in general at irb@bard.edu.

Thank you again for your participation.

Appendix E - Stimuli Examples

DISGUST EXAMPLE: 1020 - food - DIRTI Database



FEAR EXAMPLE: Animals_011_h - Nencki Affective Picture System Database (NAPS)

Appendix F - NAPS ToU

Nencki Affective Picture System (NAPS) Terms of Use

The Nencki Affective Picture System (NAPS) is the intellectual property of the Nencki Institute of Experimental Biology of the Polish Academy of Sciences and is available for research and academic non-commercial use only.

The authors ("Authors") of the NAPS shall not be held liable for any claims brought by subjects participating in research or by individuals appearing on the photographs.

The NAPS shall be used only in research projects described by the NAPS User in the form below.

The NAPS shall not be shared, distributed or otherwise provided to third parties, especially to profit-making legal entities or persons.

The NAPS shall not be exploited, used or otherwise distributed for any kind of commercial activity. Furthermore, the NAPS User shall not make the NAPS available to media organizations (television, magazines, etc.), nor make it publicly available on the Internet.

The NAPS User is requested to inform the Authors of any work performed using the NAPS and submitted for publication in an academic journal. Inclusion of images from the NAPS in a scientific publication is not allowed, except with permission from the Authors.

If the manuscript is accepted for publication the NAPS User is kindly asked to share with the Authors any collected behavioral ratings as well as the names of the pictures used in the research project described in the form below.

Appendix G - Stimuli Pair Distribution and Trial Block Groupings

Designation	Disgust Stimuli *(DIRTI)*	Fearful Stimuli *(NAPS)*	Neutral Stimuli *(DIRTI)*
D1A/D1B*	1020 food	X	1099 animals neutral
D2A/D2B	1029 food	X	1049 food neutral
D5A/D5B	1035 food	X	1042 food neutral
D3A/D3B	1120 body product	X	1141 body product neutral
D4A/D4B	1130 body product	X	1291 hygiene neutral
D6A/D6B	1135 body product	X	1194 injury neutral
F1A/F1B	X	085 animals	1098 animals neutral
F2A/F2B	X	012 animals	1097 animals neutral
F3A/F3B	X	004 animals	1250 death neutral
F4A/F4B	X	073 animals	1091 animals neutral
F5A/F5B	X	011 animals	1195 injury/infection n
F6A/F6B	X	007 animals	1193 injury/infection n

*The A and B designations refer to the counterbalanced pairings of each stimuli set. Accordingly, the stimuli designated as 'A' are stimuli sets with the emotional stimuli on the left side of the screen; those designated as 'B' are sets with the emotional stimuli on the right side of the screen

Order of Presentation	BLOCK			
	1st	2nd	3rd	4th
1	D3A	F6B	F5A	D2A
2	F3B	D6A	F4B	D5B
3	D6B	D1A	D3B	F3B
4	F1B	F5B	D5A	F6A
5	D4A	F3A	D2B	D1B
6	F4A	D4B	F1A	F2A

Appendix H - DIRTI Database Ratings of the Disgusting and Neutral Stimuli

Image Designation	Image Subject	Disgust Rating	
		Mean	SD
1 (1020 food)	moldy crabapples	4.00	2.41
2 (1029 food)	moldy cream cheese	5.14	2.56
3 (1035 food)	moldy banana	4.98	2.58
4 (1120 BP)	vomit	6.01	2.56
5 (1130 BP)	bloody sink	4.41	2.51
6 (1135 BP)	snot	5.17	2.57
1099 animals neutral	butterfly	1.07	0.48
1049 food neutral	bread basket	1.05	0.28
1042 food neutral	apples	1.03	0.22
1141 body product neutral	clean toilet	1.39	1.00
1291 hygiene neutral	blue striped towel	1.10	0.50
1194 injury neutral	hand holding rocks	1.03	0.19
1098 animals neutral	turtle	1.11	0.51
1097 animals neutral	tabby cat	1.10	0.57
1250 death neutral	seal	1.11	0.61
1091 animals neutral	bee pollinating flower	1.09	0.50
1195 injury/infection neutral	hand on post	1.11	0.43
1193 injury/infection neutral	feet in sand	1.20	0.86

Appendix I - NAPS Database Ratings of the Fearful Stimuli

Image Designation	Image Subject	Valence*		Ap-Av**		Arousal***	
		Mean	SD	Mean	SD	Mean	SD
7 (animals 085)	Lion	5.87	1.9	5.81	2.17	6.63	1.62
8 (animals 012)	Fighting Dogs	3.62	1.34	3.37	1.44	6.78	1.36
9 (animals 004)	Wolf	4.5	1.96	4.63	2.24	7.02	1.38
10 (animals 073)	Dead Lion	3.8	2.12	3.79	2.09	7.35	1.38
11 (animals 011)	Black Panther	5	2.35	5.43	2.46	7.35	1.31
12 (animals 007)	Wolf	4.76	2.05	4.8	2.19	7.06	1.52

*Valence was rated from 1 = *very negative* to 9 = *very positive*, with 5 = *neutral*
**Ap-Av is short for Approach-Avoidance referring to the likelihood of doing one or the other, it was rated from 1 = *to avoid* to 9 = *to approach*, with 5 = *neutral*
***Arousal was rated from 1 = *relaxed* to 9 = *aroused*, with 5 = *neutral/ambivalent*

Appendix J - Stimuli Rating Scale and Example

RATINGS DONE ON SCALE OF [0 to 100] or [-100 to 100]

0 = not at all

(-)7 = barely

(-)12 = slightly

(-)24 = mildly

(-)38 = moderately

(-)70 = strongly

(-)85 = extremely

(-)100 = most imaginable

Stimuli #

How disgusting do you find this?

0 10 20 30 40 50 60 70 80 90 100

How fearful do you find this?

0 10 20 30 40 50 60 70 80 90 100

How pleasant do you find this?

-100 0 100

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