The nature of fear and the pathology of trypophobia: a translational perspective

Brady Wan

Abstract

Trypophobia refers to a specific and persistent fear of clusters of holes. Phobias are common in the community (i.e., subclinical), but are usually presented in clinical settings as just one arm of a more complex anxiety diagnosis. The origins of fear-based psychopathology are overlapping and have long been investigated as a broad construct using translational paradigms (e.g., Pavlovian learning) to understand the conserved mechanisms underlying the symptoms. While many reviews on the etiological components of fear-based disorders exist, less have comprehensively integrated a truly translational perspective that highlights the significance of mechanistic research studying discrete anxiety profiles (e.g., phobias versus generalized anxiety). Here, I review literature spanning decades of research on the mechanisms that underlie phobias and discuss current debates in the field about how to interpret the evidence. Lastly, I offer novel insights about what we are missing and how we should move forward.

Keywords: trypophobia, fear, etiology

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Phobias are types of anxiety disorders where individuals experience an extreme and unreasonable fear response triggered by a specific environmental stimulus. Though often dismissed as common fears, phobias can significantly affect individuals' daily lives, leading to avoidance which can hinder their ability to function normally. Beyond emotional distress, phobias can also affect physical health, social interactions, and overall well-being. For instance, a person with severe arachnophobia may go to great lengths to avoid any interactions with a spider (e.g., going outside). It limits freedom and affects quality of life. Another example of a specific phobia is trypophobia, an aversion to clusters of small holes. Although not officially recognized by DSM-5, around 10-18% of the adult population experience it (Cole, 2024). Main symptoms include feelings of discomfort and disgust when exposed to such patterns. Unfortunately, phobias and anxiety disorders are frequently misunderstood or misused within communities. However, when clinically diagnosed, they are recognized as serious mental health conditions that require attention and treatment.

While the exact cause of fears remains unclear, researchers have proposed many theories to explain their development. These theories cover biological, psychological, and environmental factors contributing to fear, highlighting the complexity of these disorders. For example, the evolutionary perspective suggests that certain phobias, like height and snakes, evolved from adaptive responses to dangers faced by our ancestors. Additionally, different theories within neuroscience, such as the amygdala-centered theory and the two-system framework, explore how the brain processes fear. Understanding these theories is crucial for developing treatment and improving outcomes of people with phobias and anxiety disorders in general.

Theories & Frameworks of fear

The emergence of affective science spawned a variety of frameworks that help simplify the underlying mechanisms and evolutionary basis of fear. The motivation/personality theories categorize fear into five distinct types: evolutionary danger, novelty, intensity, learning, and social factors (Gray, 1987, Adolphs, 2013). Neurofunctional theories differentiate between two primary systems, fear and panic, each responsible for distinct responses to threats (Panksepp, 1998, Adolphs, 2013). From an adaptive or evolutionary perspective, fear is viewed as a critical component of a broader survival system essential for navigating potential dangers in the environment and deploying defensive responses (Ledoux, 2012). Through this theory, fear was able to evolve due to its role in life preservation, allowing organisms to respond to threats effectively.

For decades, scientists have sought to uncover a neural circuit dedicated to our experience with threat. The amygdala-centered theory emphasizes the amygdala's role in receiving and responding to sensory information about threats, forming fear memories, and controlling behavioral and physiological responses (Ledoux, 2002). The amygdala is a complex structure that consists of many nuclei that are involved in various functions, with overwhelming evidence for its critical role in managing fear responses. Importantly, there is causal evidence in nonhuman animal models supporting the amygdala's importance to fear processing (see Weiskrantz, 1956 for example).

Building on this foundation, Ledoux and Pine (2016) proposed a two-system framework that distinguishes between the behavioral and conscious aspects of fear. Behavioral and physiological responses are automatic, subconscious reactions to threats, such as increased heart rate, freezing, or fleeing. These responses are controlled by subcortical structures, including the amygdala and brainstem, and do not require conscious awareness. Conscious feeling states refer to the subjective experience of fear and anxiety, which is influenced by higher-order processes in the prefrontal cortex and other cortical regions. Unlike automatic responses, this system allows for introspection and is what individuals describe when they report feeling fear or anxiety. Importantly, Ledoux and Pine argue that the failure to distinguish between these systems has hindered progress in both scientific research and clinical treatments for anxiety-related disorders, as interventions often target one system without addressing the others.

As we continue to develop increasingly precise technologies such as more advanced neuroimaging techniques and tools, our understanding of the underlying mechanisms of fear continues to improve. Technological advancements, like functional magnetic resonance imaging (fMRI) and electroencephalogram (EEG) provide more accurate insights into the neural circuits involved in fear, as well as the psychological aspects, uncovering previously hidden aspects of how fear responses are generated and regulated. For instance, fMRI is a technology used to visualize brain activity in real-time, and can be used during fear-related tasks. By revealing neural mechanisms behind fear, it helps researchers and clinicians improve therapeutic approaches for anxiety-related disorders, ultimately contributing to more effective treatments and interventions. Thus, fMRI has proven to be an invaluable tool in advancing treatment of mental conditions.

Nonhuman animals – threat responding and survival

The ability to identify and respond to threats is central to survival across species in the animal kingdom (Adolphs, 2013). Most threat responses begin with sensory inputs, as sensory systems detect potential danger and initiate responses. Nonhuman animals exhibit a variety of responses to threats (e.g., fight, flight, and freeze), which undoubtedly correspond to distinct contextual factors. Manipulating distance and the escapability of a situation can be used as a tool to evoke defensive reactions (Mobbs & Kim, 2015). These factors play a crucial role in shaping an animal's instinctive decision to approach or escape, highlighting the complexity of threat perception and survival strategies.

Observing and interpreting animal physiology and behavior can vary greatly between different species and contexts. However, extant work on how nonhuman animals perceive and react to threat have revealed patterns of behavior and physiological underpinnings that appear evolutionarily conserved–thus, animal research has been vital for our advancement in the study of fear processing. For instance, rodents have been established as strong biological models for understanding fear across species, with the additional benefit of being relatively cheap and controllable.

Considering recent perspectives on fear and anxiety existing on a spectrum across various dimensions (magnitude, proximity) that relies on learning relationships between the self and the environment (Abend, 2024), it is no surprise that scientists have dedicated much time to studying fear within a Pavlovian framework. Pavlovian conditioning or classical fear conditioning consists of learning association between innocuous (conditioned stimulus; CS) and dangerous (unconditioned stimulus, US) items or events. In the case of anxiety, much focus has been on how threat contingencies are remembered as the evidence for a CS-US relationship diminishes. Fear conditioning studies have helped clarify the nature and underlying mechanisms of fear processing. Lesion studies in rodents have found that the amygdala is essential for processing and responding to fear (e.g., Hitchcock & Davis, 1986).

Critically, fear conditioning paradigms in rodents have been essential for understanding behavioral and biological mechanisms of fear in humans, and has led to the advancements of treatment for individuals affected by things like anxiety, panic, phobias, and PTSD.

Nonclinical

Lesion studies in humans, usually a consequence of medical anomalies, have provided pivotal insights for understanding both the psychological and neurological aspects of human behavior. Foundational work from Damasio and colleagues (2012) demonstrated how damage to the amygdala disrupts human processing in the brain. Other lesion studies (e.g., Adolphs et al., 1994) have shown similar effects of amygdala damage on fear processing, suggesting the subcortical region is critical to organizing and deploying responses to threat.

Beyond lesion studies, research on fear-related mechanisms in nonclinical samples has provided valuable insights on fear processing in the general population. One key mechanism revealed from this research is behavioral avoidance; individuals actively evade fear-inducing stimuli, which reinforces fear associations over time. Avoidance prevents the natural extinction of CS-US threat contingencies overtime, potentially underlying the development of many anxiety disorders. Some fear conditioning studies have shown that avoidance can persist even when it leads to missing out on beneficial opportunities, particularly in individuals with high trait anxiety (Pittig et al., 2014)— these findings outline the functional impairment that emerge for people with high levels of anxiety.

Somatic markers are often used to index fear responses in humans. The most common measures include skin conductance response (SCR) and fear-potentiated startle (FPS), which measure autonomic nervous system activity. Research done by Cheng et al. (2006) demonstrated that individuals with greater amygdala activation (indexed via fMRI) also exhibit stronger SCR and FPS responses, highlighting the interconnected nature of neural and physiological fear mechanisms.

Clinical

Humans, like rodents and other nonhuman animals learn associations between neutral stimuli and threat by way of Pavlovian conditioning–indeed, pathological renditions of these processes (e.g., facilitated conditioning, attenuated extinction) are thought to underlie the emergence and maintenance of fear-based disorders like PTSD, phobias, and generalized anxiety disorder (Hermans et al., 2006; Craske et al., 2018). In the case of PTSD, for instance, a person who experiences a traumatic event may develop strong associations with the neutral stimuli (certain sounds, locations, organisms) and the trauma (US; Aupperle et al., 2012). Over time, these previously neutral stimuli can evoke intense fear responses, even when the traumatic event is no longer present. Indeed, the persistence of these learned associations is governed by distributed patterns of neural circuitry that are dedicated to fear learning, notably involving the amygdala hippocampus, and the prefrontal cortex.

Research suggests that for individuals with PTSD or phobias, it may be particularly difficult to extinguish conditioned fear, leading to prolonged and exaggerated fear responses, even after evidence for a CS-US association diminishes (Wessa & Flor, 2007; Norrholm et al., 2011). Notably, similar patterns have been observed in clinically anxious youth, who exhibit stronger fear responses to conditioned innocuous stimuli compared to their non-anxious counterparts, despite showing comparable fear acquisition and extinction patterns (Dvir et al., 2019) This aligns with findings in adult anxiety populations, where individuals with anxiety disorders display impaired inhibitory learning to safety signals and stronger responses to conditioned cues, along with delayed or reduced extinction of fear (Lissek et al., 2005; Britton et al., 2014).

Trypophobia

Trypophobia, often described as fear or aversion of clusters of small holes or repetitive patterns, is a condition that has gained more attention in recent years. Although not recognized as a specific phobia in clinical handbooks (e.g. DSM-5), studies suggest that 9.7% of the population share trypophobic-like symptoms (Cole et al., 2024; Le et al., 2015). Interestingly, emerging research suggests that trypophobia may be driven more by disgust than fear. Unlike traditional phobias, which are characterized by a fear response to a perceived threat, trypophobia elicits sensory aversion (e.g., nausea or discomfort). However, its overlap with conditioned fear responses and heightened physiological arousal suggests that trypophobia may trigger processes similar to those seen in specific phobias and anxiety disorders. This aversion may be related to high-contrast patterns, with strong differences between light and dark areas, combined with patterns with both simple and moderately detailed spacing. Such visual features can cause a strong sensory reaction that may include feelings of disgust or being uncomfortable. Common trigger items for trypophobia include objects and patterns that feature clustered, repetitive holes or bumps. For example, items like honeycomb, sponges, lotus seed pods, and sometimes visual representations of skin conditions like rashes or sores usually trigger trypophobia.

The etiology of trypophobia would provide a better conceptual understanding but has remained elusive. Two prominent frameworks include the *skin-disease avoidance framework*, as well as the *danger animal framework* (Pipitone, 2022). The dangerous animal framework suggests that trypophobia may stem from an evolutionary mechanism where humans developed a sensitivity to high contrast patterns, especially in mid-range spatial frequencies, as a way to identify and avoid potentially harmful or poisonous creatures (Cole & Wilkins, 2013). This likely evolved to enhance survival by helping individuals quickly detect dangerous animals, such as venomous snakes or spiders, which often display these high-contrast patterns as a warning. Additionally, studies on visual processing and attention suggest that the human brain is tuned to detect certain features, such as contrast at specific spatial frequencies, because they may be linked to the presence of dangerous stimuli (Bannerman et al., 2012; Vuilleumier et al., 2003). This ability to process and respond to these features rapidly could have provided a survival advantage by allowing for quicker reaction to threats. Aposemtis refers to the use of warning signals, such as bright colors and distinct patterns, by potentially harmful or toxic species to alert predators to their unpalatability or danger (Ruxton et al., 2004). The concept of aposematism supports this framework, as many poisonous or dangerous animals use high-contrast colors and patterns as a visual warning to predators (e.g., wasps, poison dart frogs, coral snakes). These warning signals are evolutionary advantageous for both parties.

This framework aligns with traditional fear models, particularly evolutionary theories of fear and the two-system framework proposed by Ledoux and Pine (2016). The automatic, subconscious detection of threat-related visual patterns corresponds to the behavioral and physiological system, which rapidly triggers avoidance responses. Meanwhile, the conscious awareness of discomfort or fear related to these stimuli aligns with the subjective feeling system, reinforcing avoidance behavior. By integrating the dangerous animal framework with established fear models, we gain a clearer understanding of how these mechanisms contribute to fear responses, including those seen in trypophobia.

The skin-disease avoidance framework proposes that trypophobia may come from an evolutionary aversion to visual patterns resembling skin infections or parasitic infections. Many of the most deadly diseases as well as infections from parasitic organisms (e.g., smallpox, rubella, ectoparasites) result in irregular clusters or circle shapes on skin (Heukelbach & Feldmeier, 2004). When these patterns appear on organic matter, they may signal pathogens, helping early humans avoid infections. A study by Yamada and Sasaki (2017) recruited 856 participants who rated discomfort from trypophobic images and reported their skin health history. Their findings showed that individuals with a history of skin conditions, such as eczema or acne, reported higher levels of discomfort when viewing these images, supporting the idea that past skin issues may influence sensitivity to pathogenic cues in trypophobic patterns. Additionally, another proposed reasoning to why an evolved avoidance of skin-disease could result in aversions of seemingly-harmless objects like a sponge or honeycomb is overgeneralization (Kupfer & Le, 2018). Fear responses often extend beyond genuinely harmful stimuli but harmless ones, a characteristic commonly observed in fears and phobias (Dymond et al., 2015). This overgeneralization may lead to individuals responding with discomfort toward any object that visually resembles pathogenic cues, even if it poses no real threat. Thus, the skin-disease avoidance framework provides an evolutionary perspective on why trypophobia, a fear of clustered holes, may exist. While both frameworks provide valuable insights, many studies have argued that the skin-disease avoidance framework may more accurately account for trypophobia (Kupfer & Le, 2018; Pipitone et. al, 2022).

Interestingly, emerging literature suggests trypophobia may be characterized by disgust, rather than fear. Unlike fear, which is typically associated with perceived threats, disgust involves aversion to stimuli. In the case of trypophobia, discomfort can result in a variety of somatic symptoms, such as nausea or dizziness, but like other anxiety disorders, is not associated with an imminent threat (Pipitone, 2022). A survey study done by Barnard & Stein (2017) reported that 60.5% of participants reported mostly disgust, while only 5.1% reported mostly fear, and the remaining participants experienced a mix of both emotions. This finding suggests that disgust is a more prevalent response to trypophobic images than fear, aligning with previous research that highlights disgust as the primary emotional reaction.

Is Trypophobia a real phobia? Traditional phobias, by definition, are fear based, however trypophobia is more closely related to disgust and aversion, which does not align with the classical definition. Phobias are also typically triggered by stimuli perceived as dangerous, whereas trypophobic images are not inherently dangerous.

Although trypophobia has not been formalized in the diagnostic classification manuals and seems to be conceptually different from traditional fear-based disorders, it meets all seven criteria for a specific phobia, as outlined by Cole (2024). According to the DSM-5, a specific phobia is characterized by intense fear or anxiety about a specific object or situation, which leads to avoidance behaviors and impairment in daily functioning. The seven criteria involve an immediate response of fear or anxiety, long-term avoidance behaviors, and excessive fear response compared to the threat. Although trypophobia primarily triggers disgust rather than fear, the intensity and severity of the response are similar to those seen in phobias based on anxiety or fear. Additionally, the response is immediate upon exposure to triggers, often leads to long-term avoidance, causes significant distress or impairment in various areas of life, fulfilling all other DSM-5 criteria (Cole, 2024).

Notably, the movement towards dimensional classification systems like the Research Domain Criteria (RDoC) and the Hierarchical Taxonomy of Psychopathology (HiTOP), has provided alternative frameworks for understanding mental health conditions. Unlike the DSM-5's categorical approach, which treats disorders as separate conditions with specific diagnostic criteria, dimensional models emphasize the continuous nature of psychological traits and symptoms. Instead of placing disorders into strict diagnostic categories, these frameworks recognize that psychopathology exists in a spectrum, with varying degrees of severity as well as overlap between different conditions.

RDoC focuses on underlying neurobiological and behavioral dimensions to bridge the gap between neuroscience and clinical psychology. It identifies major factors involved in mental health such as fear processing, reward sensitivity, and cognitive control. RDoC seeks to understand disorders in terms of problems in these processes rather than seeing them as separate conditions.

Similarly, HiToP organizes symptoms into hierarchical spectrums, grouping related disorders based on shared characteristics rather than treating them as completely different conditions. For instance, anxiety and depressive disorders are often coexisting, and HiToP captures this overlap by placing them in a broader internalizing spectrum. This approach helps account for high rates of symptom co-occurrence, offering a more efficient way to conceptualize mental health conditions.

Overall, dimensional frameworks like RDoC and HiTOP offer a more effective approach than the DSM-5 to understand conditions like trypophobia and other specific phobias. They account for things like symptom overlap and individual variability, which categorical models like the DSM-5 tend to overlook.

Treatment

Advances in research have led to the development of different therapeutic approaches that target specific parts of fear processing, like exposure therapy and extinction learning, which directly target unfavorable fear responses and encourage the formation of non-threatening associations. Research, such as the inhibitory learning model proposed by Craske et al. (2014), emphasizes that the effectiveness of these approaches depends on replacing fear responses by creating new associations, rather than reducing the intensity of fear during exposure.

First-line treatment for fear-based disorders includes exposure. Exposure is when individuals are gradually introduced to feared situations or stimuli in a controlled manner to reduce fear. This works by forming new associations with the feared stimulus and replacing fear and avoidance with a sense of safety and reduced arousal. For example, a patient with social anxiety will benefit from opportunities for social engagement until the fear and avoidance of social interaction is reduced. Indeed, exposure is analogous to extinction learning in that it involves repeated exposure to feared stimuli without consequences, leading to a weakening of original fear responses. Craske et al. (2014) argue that optimizing exposure involves maximizing expectancy violation–creating scenarios that defy the individual's expectations–which promotes deeper and more durable learning. Depending on the individual, exposure may be set-up in a variety of ways: in vivo exposure (real-life exposure), imaginal exposure (visualizing feared situations), interoceptive exposure, which intentionally produces a feared physical sensation (e.g. racing heart) to extinguish conditioned associations, graded exposure (progressive steps towards confronting fear), and more.

Considering the limited clinical resources for trypophobia, the procedure for introducing and carrying out exposure treatment is not well established for the specific disorder. However, considering its similar pathology to other specific phobias, it may be advised to develop a gradual exposure hierarchy, starting with less triggering stimuli. This would progress overtime by introducing more fear-inducing images or situations, while including techniques to manage distress such as controlled breathing or relaxation exercises (e.g., meditation). Additionally, treatment could focus on promoting different responses through structured exposure rather than adapting to images. For example, individuals may first be exposed to things like honeycombs or art, and vary stimuli, such as texture or lighting to prevent rigid associations and support adaptive emotional responses.

Future Directions

Despite theories for trypophobia (i.e., skin-disease avoidance & dangerous animal frameworks), its cause still remains largely unknown, highlighting the need for further research to understand its underlying mechanisms. Future research should aim to identify exact causes of trypophobia to help guide the development of more targeted and effective clinical interventions. Developmental studies could explore when and how people develop an aversion towards trypophobic images, helping to determine different factors that contribute to its emergence. Additionally, work should be done to reduce stigma around seeking treatment for mental health conditions in general, improving accessibility to those in need.

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