The Origins of Boredom

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Abstract

Why do people experience unpleasant, aversive emotions? Boredom is associated with a wide range of mental and physical health problems, including binge eating, substance use, anxiety, and depression. Nor does boredom feel good; many people are willing to shock themselves or even view upsetting images rather than be bored. Given such evidence, is it possible that boredom has adaptive value? We argue that it does; boredom provides an important evolutionary solution to minimizing prediction error by incentivizing learning. Reducing prediction error, it has been argued, is a core organizing principle underlying cognition; however, one way to reduce error is to isolate one's self in extremely predictable environments (i.e., the "Dark Room Problem"). We argue that boredom evolved, at least in part, to prevent this. Specifically, boredom makes such a solution affectively undesirable, by aversively signaling a lack of successful attentional engagement in a valued goal-congruent activity. To reduce this aversive state, people are motivated to re-engage in meaningful activities and reallocate attentional resources. We review evidence from behavioral science and computational modeling supporting the role of boredom in maximizing learning and reducing prediction error. Furthermore, we suggest that these functions of boredom are not only present in modern humans, but have been conserved across species. We review evidence for boredom-like states in non-human animals and argue that animals likely experience boredom due to sharing many of the same psychological and physiological components of emotion as humans. For instance, animals in under-stimulated environments, such as cages or zoos, exhibit stereotyped behavior and other responses analogous to boredom in humans, including novelty seeking and play. In doing so, we address the adaptive value of boredom and its origins and prevalence in both human and non-human animals.

Keywords: Boredom, evolution, meaning, attention, adaptive

《约客》赵师秀

黄梅时节家家雨，青草池塘处处蛙。
有约不来过夜半，闲敲棋子落灯花。

In Summer rain comes a-knocking at homes here and there;
In the green grass and ponds croaking frogs are everywhere.
Past midnight, my friend who says he would come is not here;
I rap on the chess pieces in leisure,
And knock off the lamp's burnt wick with pleasure.

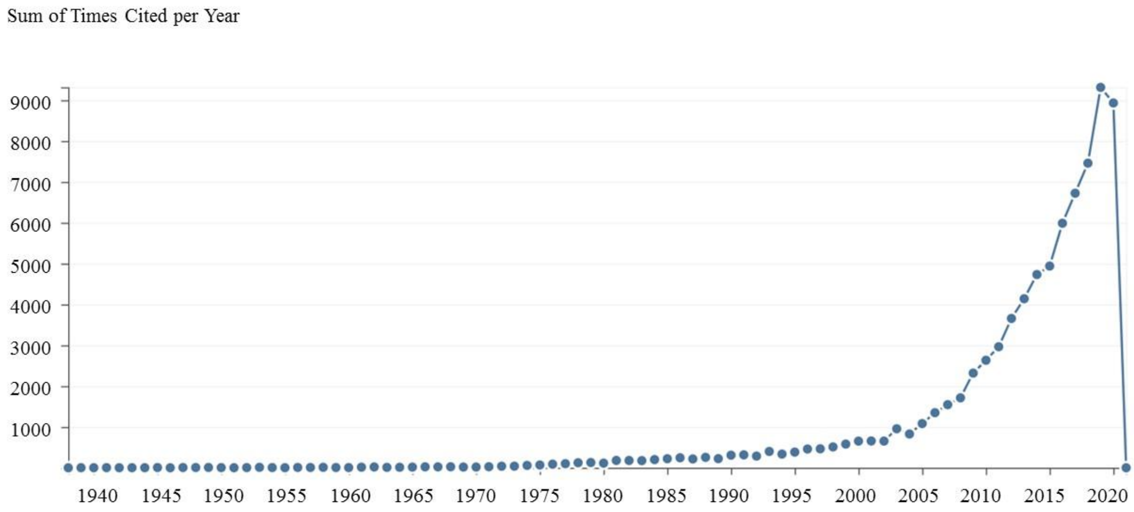
– Zhao Shixiu (1170-1219), “Appointment with a Friend”

More than a thousand years ago, boredom surfaced in the works of ancient Chinese poets. Zhao Shixiu, from the Southern Song dynasty, described his efforts to “while away” boredom as he waited up at night for a friend. Bored, he occupied himself fiddling with a chess set and lamp wick. Tapping out soft sounds to break the silence of the night may have been the ancients’ solution to boredom. However, more than a thousand years later, how does boredom present itself?

Although many of us couldn’t be more familiar with it, boredom is one of the most understudied negative emotions in psychology. According to the Web of Science, researchers published only 4,751 articles on boredom from 1864 to 2020 (Clarivate Analytics, 2020; see Figure 1), compared to fear (with 181,560 publications) or anger (41,616 publications). Despite this historical lack of scholarly interest, boredom is extremely common (Chin et al., 2017). In a sample of 3,867 American adults, 63% of participants experienced boredom at least once during a 10-day span (Chin et al., 2017), with rates highest among men, teenagers, unmarried adults, and low-income households.

Figure 1

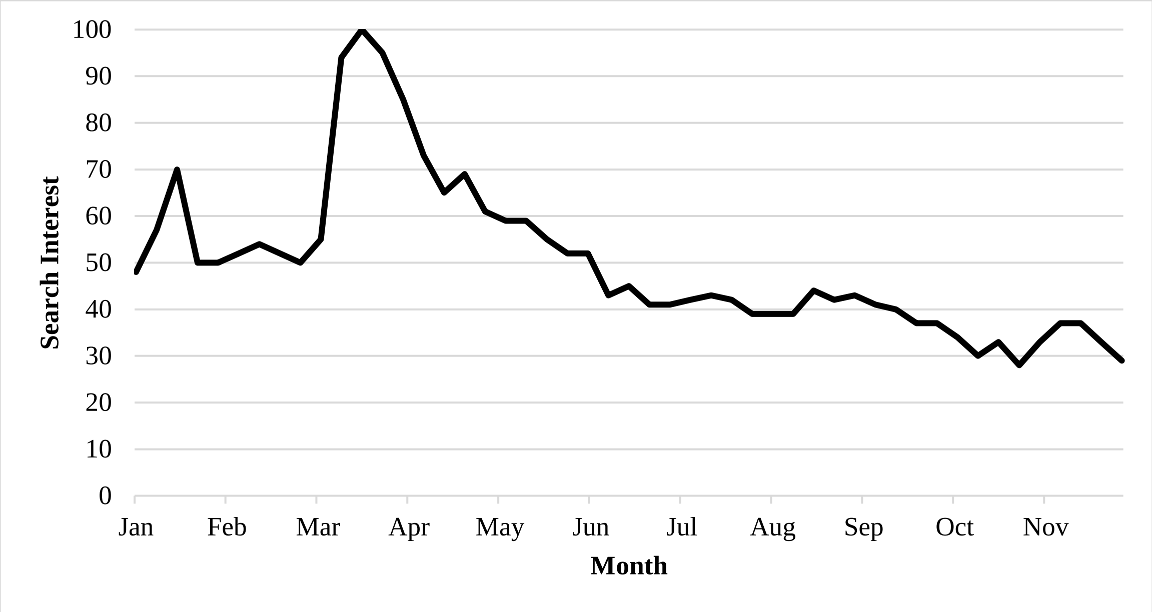
Scholarly citations for boredom-related publications from 1864 to 2020



Surprisingly, boredom occurs even during situations when it might seem counterproductive. At the beginning of the U.S. coronavirus outbreak, Google Trends saw a spike in searches for "boredom topic" (an aggregate of search terms classified internally by Google as relating to boredom) in March of 2020 (see Fig 2). At the time, most restaurants and movie theaters were closed; many states required residents to stay home to reduce infection. Surely it would be adaptive, in such a situation, to do so happily and enjoy the extra time afforded by freedom from commuting and overwork. Yet, instead, newspapers filled with anecdotal reports of people in lockdown feeling bored (e.g., Rosenwald, 2020; McAlinden, 2020; Friedman, 2020); some of whom felt tempted to violate social distancing restrictions (Boylan et al., 2020). That boredom can lead to negative outcomes has been widely documented: experimental studies show boredom increases willingness to harm one's self (Wilson et al., 2014; Nederkoorn et al., 2016; Havermans et al., 2015) and others (Pfattheicher et al., 2020). And correlational data link boredom to a wide range of negative public outcomes, including substance use and drug-related mortality (e.g., Baldwin & Westgate, 2020; Iso-Ahola & Crowley, 1991).

Figure 2

Google searches for "boredom topic" in the United States (2020)



Note. Numbers represent search interest relative to the highest point on the chart for the given region and time. 100 = peak popularity, 50 = half as popular, 0 = insufficient data available.

In short, boredom does not seem adaptive. People tolerate, and often respond to it, poorly, despite its prevalence. But why would we continue to experience boredom if it perpetuates maladaptive behaviors? To understand this paradox requires exploring the evolutionary origins of boredom, and the adaptive function of negative emotions more generally. In this chapter, we propose that although boredom is an aversive, unpleasant state that often produces seemingly maladaptive behaviors, it provides an important evolutionary solution to minimizing prediction error and facilitating learning. People and non-human animals alike are motivated to re-engage in meaningful activities and reallocate attentional resources to reduce boredom. In doing so, boredom maximizes strategies favoring exploration and discovery, and fosters long-term goals pursuit and learning.

Boredom-as-Information

Affect, behavior, and cognition exist today because of their adaptive value in the past (e.g., Darwin, 1864; Dawkins, 1976). Many theories posit that emotion plays an important role in helping organisms adapt to and survive in their environments (Plutchik, 1980). For instance, when confronted by basic needs for safety and sustenance in the face of danger, fear can be an important defensive tool. Without fear, organisms are hampered in appropriately evaluating or navigating the dangers of their environment, greatly reducing odds of survival (e.g., Misslin, 2003; Lebel, 2016). According to prominent theories, fear and other forms of negative affect thus act as a "stop" signal, alerting us to problems in the environment, while forms of positive affect act as a "go" signal, alerting us that all is well (Clore & Huntsinger, 2007; Storbeck & Clore, 2008; Huntsinger et al., 2014).

Specifically, theories of affect-as-information propose that automatic appraisals of situations provide conscious information in the form of affect and emotions, processes shaped by our subjective experience and attributions (Clore et al., 2001). Such informative affective states help us survive, reproduce, and flourish. Boredom, like all emotions, is thus a source of important information about whether we are productively engaged with our environment. However, this interpretation of boredom requires a rethinking of many traditional models of emotion. According to the "Classic View of Emotion" (Bliss-Moreau, 2018), basic emotions reflect underlying biological units and adaptive values; each basic emotion has its own corresponding unique pattern of facial expressions, physiological processes, and behavioral reactions (e.g., Darwin, 1872; Izard, 1992; Ekman, 1992). One consequence of this theoretical framework is the assumption that we should be able to measure and identify specific emotions using non-verbal markers, such as facial expression, and physiological and neural markers. The Classic View of Emotion generally assumes that emotion has been consistently shaped by evolutionary adaptation and thus is consistent across species and cultures.

However, extensive empirical evidence questions these assumptions. First, modern evolutionary approaches to emotions disagrees with this distinction between basic and non-basic emotions (Al-Shawaf et al., 2016; Al-Shawaf & Lewis, 2017), because many emotions, such as envy (e.g., DelPriore, Hill, & Buss, 2012), embarrassment (e.g., Keltner & Buswell, 1996), and romantic love (e.g., Hazan & Shaver, 1987), are applicable to a wide range of adaptive problems related to mating, reproduction, and childrearing. Second, while many studies have suggested that certain emotions should be universal, empirical counterexamples are easily found. For instance, when asked to sort images of posed and unposed facial expressions, participants from the Himba ethnic group do not show the "universal" pattern exhibited by Americans, because they hold different antecedent knowledge of emotional concepts. Because culture and language shape emotion concepts, people in different cultures thus categorize and express emotions in different ways (Gendron et al., 2014). Third, while many researchers have argued that emotions have discrete facial expressions and physiological markers (Keltner et al., 2006; Cordaro, 2021; Cowen et al., 2021), recent meta-analyses call these findings into question. Aggregated across many such individual studies, these meta-analyses find that specific emotions cannot be reliably differentiated by physiological responses (Siegel et al., 2018), facial expressions (Barrett et al., 2019; Gendron et al., 2014), or neural dynamics (Lindquist et al., 2012). That is, researchers cannot accurately predict which specific emotion a person is experiencing simply by observing seemingly "objective" characteristics, such as their heart rate, smile, or amygdala activity. Rather, differences *within* an emotion (e.g., expressions of anger) are often as great as the differences *between* emotions (e.g., expressions of anger vs sadness; Barrett, 2009).

What is the crucial factor in emotion formation if not specific differences in physiological or neural features? Theories of Constructed Emotion (Bliss-Moreau, 2018), including appraisal theories, argue that instead we must look to the situations that elicit emotions, and – specifically – to people's construals (e.g., Barrett, 2006; Clore & Ortony, 2013). Thus, while basic affect (e.g., valence, arousal) may be physiological in nature, it is how we categorize and interpret that affect which determines the specific emotions we feel (e.g., Schachter & Singer, 1961; Dutton & Aron, 1974). And because construal mediates the journey from affect to emotion, emotions vary across individuals, situations, and cultures (Cannon, 1927; Potthoff et al., 2016).

The Key Ingredients of Boredom: Meaning and Attention

The dictionary defines boredom as the state of being weary and restless through lack of interest (Merriam-Webster, 2020). However, psychological definitions focus instead on the *causes* of boredom, rather than its prototypical symptoms or experiential components. In short, people feel bored when unable to engage their attention in valued-goal congruent activity (Westgate & Wilson, 2018). According to the Meaning and Attentional Components (MAC) model, boredom thus has two components – meaning and attention.

Attention deficits. Boredom is caused, in part, by attention deficits. When attention and meaning are both entered as simultaneous predictors of boredom, attention independently predicts boredom (b = .34), even after controlling for meaning (Westgate & Wilson, 2018). External distractions reduce boredom on simple but not complicated tasks (Damrad-Frye & Laird, 1989; Fisher, 1998), and when attention is manipulated experimentally, participants find an overly easy version of an air traffic control task (i.e. inattention) more boring (M = 7.77, SD = 1.46) than a challenging version (M = 7.27, SD = 1.57). Nor is boredom due solely to under-stimulation (Eastwood et al., 2012; Cziskzentmihalyi, 2000). Both under- and overstimulation create a mismatch between cognitive demands and mental resources that makes it difficult to maintain attention (Berlyne, 1960; Westgate & Wilson, 2018; Wickens, 1991). For instance, people feel *more* bored when an air traffic control task is either too easy or too hard (and *less* bored when it is "just right"), and experimental manipulation of cognitive demands replicate this effect (Westgate & Wilson, 2018; Westgate et al., 2017).

Meaning deficits. At the same time, meaning deficits can also cause boredom. When entered as simultaneous predictors in correlational studies, meaning significantly predicts boredom (b = -.35), even after controlling for attention (Westgate & Wilson, 2018). Likewise, meaningless repetitive tasks lead to boredom (Van Tilburg & Igou, 2012, 2017), and experimentally endowing otherwise monotonous tasks with meaning (via charitable contributions or utility value interventions) reliably reduces boredom (Hulleman et al., 2010; Schmeitzky & Freund, 2013; Westgate & Wilson, 2018).

Different ingredients, different experiences. Although it might seem reasonable that meaning and attention would interact, empirical evidence to date suggests this is not the case. For instance, in a meta-analysis of 14 correlational studies (Westgate & Wilson, 2018), while both meaning (b = -.35) and attention (b = .34) predicted boredom when entered as simultaneous predictors of boredom in a regression, they were not highly correlated (r = -.12), and did not interact (b = .005, 95% CI [-.03, .04]); experimental results simultaneously manipulating attention and meaning replicate this lack of interaction (η_p^2 = .004, p = .37).

These qualitatively different causes of boredom may also result in qualitatively different *experiences* of boredom. For instance, inducing boredom via attentional deficits results in greater inattention (but not greater disengagement, agitated affect, dysphoric affect, or distorted time perceptions; Westgate & Wilson, 2018), which mediated its effect. Likewise, inducing boredom via meaning deficits results in greater disengagement, agitated affect, dysphoric affect, and distorted time perception (but not inattention), all of which in turn mediated the effect of the meaning manipulation.

Boredom-as-Information. In short, boredom, like fear and other emotions, behaves as an affective alarm that signals us to a lack of meaningful engagement in the environment. This can occur when activities are not personally meaningful or do not offer a good fit for current resources. Moreover, these causes can inspire different strategies for reducing boredom. If we are bored due to a lack of meaning, then we can reappraise activities in ways that make it more valuable or goal-consistent (or, disengage and pursue a more meaningful activity). If, however, we believe we are bored because it is hard to pay attention, then we can adjust either the task's difficulty or our own cognitive capacity (or, disengage and pursue a more optimally challenging activity). In this sense, boredom offers a powerful source of information about our lives, guiding us towards activities that are appropriately challenging and meaningful, and steering us away from activities that are not. In doing so, boredom maximizes opportunities for optimal learning.

The Boredom Paradox

Yet, if boredom is so useful, why is it implicated in such a broad range of problematic societal and individual outcomes? Below we briefly review this formidable challenge to our argument for boredom's adaptive nature, before introducing several possible explanations that reconcile both the benefits and risks of boredom to explain why it has persisted.

Mental health risks. Boredom co-exists with other negative emotions, including loneliness, anger, sadness, and worry (Chin et al., 2017), and both trait and state boredom are positively associated with anxiety and depression (e.g., Sommers & Vodanovich, 2000; Chao et al., 2020). In the workplace, boredom is associated with fatigue and dissatisfaction (Skowronski, 2012), and people are willing to voluntarily hurt themselves to reduce boredom.

For instance, 67% of men and 25% of women gave themselves at least one shock rather than be bored with their own thoughts for 15 minutes (Wilson et al., 2014). Such harm may also be directed outwards. Trait boredom is associated with higher levels of anger and aggression (Dahlen et al., 2004), and across 15 studies and over 7,000 participants, researchers found boredom causes sadistic behavior (Pfattheicher et al., 2020). People high in trait boredom reported more online trolling and fantasies of shooting people, robbing banks, and revenge. Bored soldiers behaved more sadistically towards coworkers, and bored parents behaved more sadistically towards their kids.

Physical health risks. In addition to mental health, boredom is associated with a number of health risk behaviors and outcomes. For instance, both trait and state boredom have been associated with binge eating (Moynihan et al., 2015) as well as substance use, including alcohol (Orcutt, 1984; Westgate & Fairbairn, 2020) and marijuana (Willging et al., 2014; but see Wegner, et al., 2008 and Block, et al, 1998). In big data from Google search and government records, regional increases in boredom are associated with maladaptive public health across all 50 US states. Boredom searches are associated with higher drug-related mortality and more frequent drug abuse searches, as well as more frequent self-harm searches (Baldwin & Westgate, 2020). Boredom has also been associated with worse sleep quality, due to inattention and bedtime procrastination (Teoh et al., 2020).

Self-regulation failure. Boredom may also form an important link in self-regulation and explain behaviors such as procrastination (Blunt & Pychyl, 1998; Vodanovich, & Rupp, 1999; Wan et al., 2014). Procrastination shares many of the same sources as boredom, according to the MAC model. For instance, people are more likely to procrastinate on a task when it feels meaningless (Lee, 2005); feelings which are also likely to increase boredom. Likewise, the mismatch of attentional resources makes it more difficult to concentrate on important tasks, which increases boredom and makes distraction more likely (Ferrari, 2000).

Is it causal? Much of the above research is correlational, or reflects differences in boredom-proneness or trait boredom (which might be explained by confounds or third variables; see Westgate & Steidle, 2020). However, experimental studies suggest that boredom plays a causal role in many of these outcomes. For instance, experimentally induced boredom increases pursuit of novel experiences, even if those experiences are negative (Bench & Lench, 2019). The same is true of physically painful experiences. For instance, Havermans and colleagues (2015) found that participants delivered more electric shocks to themselves over the course of an hour spent watching an 85-second documentary clip on repeat (vs watching the full documentary). Likewise, participants randomly assigned to a boredom induction administered more electric shocks to themselves than those assigned to sadness or control conditions (Nederkoorn et al, 2016). Across a series of experiments (Pfattheicher et al., 2020), participants assigned to watch a boring video were more likely to kill helpless worms and deduct monetary payments from other participants for no personal gain, compared to those assigned to watch a fun video. They were also more likely to monetarily punish wrongdoers for past bad behavior. Finally, experimentally inducing boredom increased people's consumption of chocolate (Havermans et al, 2015), and desire to eat (especially unhealthy) snacks (Moynihan et al., 2015).

In short, boredom is associated with a wide array of negative outcomes, from individual mental to societal health risk behavior. This presents a troubling paradox: if boredom is adaptive, why is it so often associated with maladaptive behaviors and outcomes?

The Origin of Boredom

Drawing on the above, we propose five explanations for why boredom persists despite its apparent drawbacks. In short, we theorize that the potential costs of boredom (e.g., in environments with limited opportunity or constrained choice) are outweighed by the potential benefits that boredom confers. Importantly, we argue that boredom maximizes strategies favoring exploration and discovery, and promotes learning. In doing so, boredom offers an important evolutionary solution to minimizing prediction error and achieving homeostasis. We outline the ways in which it does so below.

Emotions as feedback. Traditional theories suggest that emotions "trigger" behavior, reliably and directly. But recent work suggests that instead of directly causing behavior, emotion provides feedback regarding our behaviors' consequences (Baumeister et al., 2007). Acting kindly feels good (encouraging future kindness), while acting meanly may feel good in the moment, but later makes us feel bad (discouraging future meanness). Boredom "punishes" behavior lacking in meaning or optimal attentional engagement, encouraging people to disengage from those behaviors in the present, and making such behavior less likely in the future. In other words, the negative affect that accompanies boredom negatively reinforces an individual's decision to engage (or disengage) in it.

Stimuli gain positive and negative affective value when they break homeostasis (Barrett & Simmons, 2015), or the delicate physiological balance between a person's internal physiological resources and external environmental demands (Lerner, 1954). Affect is thus an easy and "cheap" way for the body to inform the conscious mind that homeostasis is under threat, while specific emotions (such as boredom) helps us pinpoint the causes of negative affect and restore homeostasis. For instance, when people respond to boredom with sadistic behavior, they do so to remedy deficits in attention by seeking stimulation, rather than restoring meaning (Pfattheicher et al., 2020). Without specific emotions, we might feel "bad" but without a clear sense of why; and without knowledge of the underlying problem, the causes of negative affect become harder to address

This feedback not only shapes behavior in the moment, but changes predictions for how future behavior will make us feel. Learning from current emotion-behavior patterns allows people to generalize to future events. Upon encountering similar situations, such evaluations occur automatically, allowing for optimal decisions with minimal cognitive effort. For instance, a graduate student who suffers through boring statistics courses may inadvertently learn to avoid statistics. Boredom, like other emotions, thus serves as an intrinsic motivational system, rewarding and encouraging certain activities, while discouraging others.

Minimizing opportunity costs. One consequence of such feedback is that boredom minimizes opportunity costs, the loss of potential gain from other alternatives when a person chooses one particular alternative (Kurzban et al., 2013). Many theorists argue that boredom's primary purpose is to signal such opportunity costs and is primarily triggered by the perception that such costs are occurring (or are imminent; e.g., Wojtowicz et al., 2020). Thus, boredom is theorized to occur when benefits do not offset costs, motivating us to recompute the benefit-cost ratio, disengage from the current task, and reallocate our resources (Kurzban et al., 2013; Agrawal et al., 2020). For instance, when placed in a room with alluring alternatives (e.g., a laptop, puzzle), participants report greater boredom while thinking than when stuck in an empty room (Struk et al., 2020), because opportunity costs are more salient.

Because boredom signals that we are engaged in a meaningless activity, or unsuccessfully engaged in a target activity, or both, boredom serves as a dynamic evaluation of such motivational and cognitive costs. Persisting at activities when we have neither the motivation nor ability to do so puts us in the position of forgoing better alternatives – ones that may be more meaningful, or which would be more successful at.

Maximizing learning. By motivating people to seek out optimally challenging and meaningful activities, boredom maximizes opportunities for learning. Evidence from behavioral science and computational modeling supports this role. For instance, people who take challenging coursework in college, or who study abroad, report their lives are psychologically richer (and less boring; Oishi & Westgate, 2021) as a result, and think about the world in more complex ways (Oishi, et al., 2021). In an experimental setting, bored participants were more inclined to choose novel imagines, even a novel more negative image (Bench & Lench, 2019).

Evidence from reinforcement learning more directly demonstrates the role of boredom in promoting learning. Curiosity drives learning progress, yet as an independent driver has its limitation – curiosity blocks learning agents from certain outcomes and can produce obsessive habitual actions because curiosity alone cannot inform agents about prior exposure to similar situations. Unlike curiosity, boredom *can* detect repetitive exposure and devaluate known outcomes. Thus, both curiosity and boredom as internal rewards make knowledge acquisition a dynamic, goal-directed process and maximize learning outcomes and minimize opportunity costs (see Schmidhuber, 1991; Yu et al., 2019). Experiments show that, compared to conventional reinforcement learning, models adding curiosity and boredom as dual internal rewards yield better performance on maze navigation tasks by reducing prediction error and increasing external rewards (Yamamoto & Ishikawa, 2010).

Fostering exploration. One way that boredom maximizes learning is by fostering exploration. Other animals (such as chipmunks) navigate the fundamental trade-off between exploitation and exploration by, for instance, spending more time *exploiting* high quality food patches, but more time *exploring* alternatives when patch quality is low (Krebs et al., 1978; Mehlhorn et al., 2015; Kramer & Weary, 1991). Such strategies are also common among humans. For instance, the abnormally prolonged period of human childhood is thought to offer an evolutionarily advantageous extended period of exploration (Gopnik, 2020).

Boredom may play a similar role for adults, by increasing novelty seeking (Bench & Lench, 2019) and willingness to take risks (e.g., Wegner & Flisher, 2009). People report greater boredom in environments with little information, which in turn increases exploratory behavior (Geana et al., 2016). Experimentally induced boredom increases pursuit of novel experiences, even if those experiences are negative (Bench & Lench, 2019). Participants who viewed a neutral image set 10 times (vs 0 times or 3 times) were more inclined to subsequently request to view a novel negative (vs neutral) image. Evidence from reinforcement learning likewise suggests that boredom elicits exploration to reduce boredom (Gomez-Ramirez & Costa, 2017). Boredom thus signals a need to switch between exploration and exploitation, thereby minimizing opportunity costs (Danckert, 2019). For instance, people are less satisfied with their relationships when they perceive their partners are bored (Dobson et al., 2020), which may prompt them to end the relationship and explore alternatives.

Reducing prediction error. One consequence of the above processes is that boredom may be an important feedback mechanism for optimally reducing prediction error. Reducing prediction error, it has been argued, is a core organizing principle underlying cognition. However, one way to reduce error is to isolate oneself in extremely predictable environments (i.e., the “Dark Room Problem”, Sun & Firestone, 2020), where there’s no way to learn and explore. We argue that boredom evolved, at least in part, to prevent this. Specifically, boredom makes such a solution affectively undesirable, by aversively signaling a lack of successful attentional engagement in a valued goal-congruent activity. To reduce this aversive state, people are motivated to re-engage in meaningful activities and reallocate attentional resources, which maximizes learning.

In particular, boredom may act as a brake on strategies that reduce prediction error primarily via reducing environmental complexity. Such understimulation produces boredom, which prompts people to regulate their environments by seeking out greater complexity – forestalling the problem of the “dark room” (e.g., Gomez-Ramirez & Costa, 2017). At the same time, such increases in complexity spur greater opportunities for learning. For instance, when reinforcement-learning models are programmed to use curiosity and boredom as internal rewards, boredom outperforms curiosity, leading to greater gains in learning and ability to predict the environment (Schmidhuber, 1991; Yamamoto & Ishikawa, 2010; Yu et al., 2019). Boredom thus creates a state of homeostasis that optimizes the reduction of *global* prediction error, by forestalling strategies that rely on reducing *local* error (e.g., via understimulation) as well as those that result in environmental complexity too great to effectively process (e.g., overstimulation).

Beasts of Boredom

Boredom and its precursors, we argue, may serve as a basic motivational mechanism not only for humans, but among many non-human animals as well. Below, we review evidence for boredom-like states in non-human animals, and argue that animals may experience boredom due to sharing many of the same psychological and physiological components of emotion as humans.

Whether non-human animals experience emotion is hotly debated. One obvious difficulty is that we cannot simply ask a dog or a fish (or an octopus) what they are feeling. Cosmides & Tooby (2000) suggest that we can characterize an emotion, in both humans and non-human animals, according to its situations and cues, because emotion is a superordinate program that detects, coordinates, and solves adaptive problems. And yet, extensive research in human populations suggests that the best and most accurate method of measuring emotion is direct self-report (Robinson & Clore, 2002). This is also a problem for the classic view of emotion; although such approaches view emotions as specific physiological and behavioral reactions, these interpretations cannot be verified without animals' self-reported emotions (Bliss-Moreau, 2017). For instance, a mouse may freeze because it is afraid – or because it is happy, bored, or simply contemplating its next actions. Instead, theories of constructed emotion provide an alternative approach to deconstructing animals' emotions, by suggesting that affect (i.e., the experience of valence and arousal that forms the basis of emotions) *is* conserved across species (Russel, 2003). Affect is the product of disequilibrium between organisms and their environment, which serves the purpose of signaling stimuli that are harmful or beneficial for survival. With this approach in mind, while we may not be able to ask an octopus what it is feeling, we can measure the ingredients that make up emotion (e.g., core affect, attention, and predictive coding; Bliss-Moreau, 2017; Bliss-Moreau, Williams, & Karaskiewicz, 2018) through physiological and behavioral means. In particular, we can examine whether non-human animals share the psychological prerequisites for emotional experience in humans: affect, conceptual knowledge, social context, and (possibly) language.

Do animals share the same emotional experiences as humans? Possibly. Since many emotions serve as a predictive signals to evaluate the relationship between organisms and their environment, some emotions (and their corresponding consequences) should be consistent across species. One way to examine this question is to observe whether certain situations elicit behavioral responses in non-human animals that are analogous to those observed in bored humans in similar situations. For instance, under-stimulation has been widely documented as a cause of self-reported boredom in humans (Eastwood et al., 2012; Cziskzentmihalyi, 2000). Likewise, animals in under-stimulated environments, such as cages or zoos, exhibit responses analogous to boredom in humans, including stereotyped behavior, novelty seeking, and play behavior (Burn, 2017). Likewise, boredom-like states in animals may cause maladaptive behaviors similar to that in humans. For instance, pigs housed in non-enriched conditions for 5 months showed reduced behavioral diversity compared to those housed in enriched conditions (Wemelsfelder et al., 2000). Stereotypic behavior has been observed in caged animals such as mink and mice, although its relationship with boredom remains unclear (Meagher et al., 2017).

If boredom is adaptive in human adults, then we should see it (or its precursors) in both human children and non-human animals. That non-human animals are sensitive to under- and over-stimulation has been widely documented, suggesting a mechanism parallel to that of the attention component in humans. Furthermore, evidence for a meaning-like component comes, perhaps somewhat unexpectedly, from the long history of animal research on learning and operant conditioning (Skinner, 1963). Such research clearly shows that non-human animals, including pigeons, cats, and the great apes, respond with more interest and engagement to high-value rewards (e.g., M&Ms) than low-value rewards (e.g., cucumber), and that such engagement produces greater learning (e.g., Egan, Santos, & Bloom, 2007). In humans, construing current activity as congruent with valued goals is felt as a heightened sense of meaning, and increasing value in analogous ways (e.g., monetary contribution to a charity) creates parallel effects (Westgate & Wilson, 2018). And like in humans, these states appear adaptive: just as humans seek cognitive engagement and meaning to get rid of boredom, animals experiencing boredom-like states also seek out novel stimuli and enriched environments. For instance, non-enriched mink showed stronger interest in stimuli (consistent with boredom-like states) compared to enriched mink (Meagher & Mason, 2012; Meagher et al., 2017). And boredom, argues Burns (2017), motivates animals to explore their environment and learn new things, which facilitates the identification of environmental resources and dangers.

In sum, boredom-like states appear common in animals, and appear to be elicited by the same situational factors that cause boredom in adult humans, with similar behavioral consequences. This may also be true of young human children. One-year-old infants exhibit a boredom-like state when presented with uninteresting stimuli (Kagan & Lewis, 1965); and evidence from linguistic studies suggests that by the age of seven, children understand the meaning of boredom (although only half of children do so at age four; Nook et al., 2020). This trend becomes even more robust by adolescence and pre-adolescence; for instance, leisure boredom in German children modestly increased from the ages of 10 to 14 (Spaeth et al., 2015). The above evidence suggests that boredom-like states may be common in children and non-human species; yet whether they share the same experiential features, much less causes and consequences as in human adults, is a topic of much-needed research.

Making Boredom Adaptive

We argue emotions are adaptive, but boredom has been predominantly linked to *negative* outcomes. Generally speaking, features that hamper the odds of survival and reproduction are less likely to be retained and thus gradually disappear (Darwin, 1864). From this perspective, the capacity to experience boredom should have been heavily selected against. Why then is boredom so common? We suggest two possibilities: 1) that while boredom is often the source of many negative outcomes, its negative effects may depend on people's lay beliefs, and 2) that whether boredom is positive or negative is a function of the environment. In particular, we explore the role of environmental mismatches between ancestral and modern environments.

Bringing the Person Back to the Situation

Believing boredom to be bad may be a self-fulfilling prophecy (Rosenthal, 1974). In a meta-analysis of over 19,950 adults, negative attitudes towards depressive affect had a particularly strong association with depression (Yoon et al., 2018). That is, believing that depression was bad made the actual experience of depression worse. Similarly, negative beliefs about boredom may aggravate its experience. Evidence from cognitive-behavioral therapy suggests that changing maladaptive beliefs about emotion can beneficially impact well-being (Corstorphine, 2006; De Castella et al., 2015), and believing emotions to be malleable may diminish the maladaptive outcomes brought by negative emotions (Tamir et al, 2007; Kneeland et al., 2016).

A growing body of evidence suggests that boredom promotes meaning-seeking activity (e.g., van Tilburg & Igou, 2017). Feeling bored is linked to better performance on tasks accessing associative thought, a key component of creativity (Gasper & Middlewood, 2014), and boredom is related to mind-wandering, a kind of attention deficit conducive to creative problem-solving (Mooneyham & Schooler, 2013). For instance, people who completed a boredom induction (followed by a creative task) came up with a higher number of uses for a pair of polystyrene cups than participants who completed the creative task first (Mann & Cadman, 2014). Although many of these studies rely on small sample sizes, they suggest that positive outcomes of boredom may be possible.

Thus, we predict that if people believe boredom is bad, they are more likely to behave badly when bored; if people believe in the beneficial value of boredom, they are more likely to behave constructively. Finally, as a cautionary note, we observe that if researchers are predisposed to believe that boredom leads to negative outcomes, they may be more likely to look for such associations, leading to a cycle of research that may inadvertently skew the apparent distribution of the boredom-behavior relationship.

The Person-Environment Fit

Environments powerfully shape people’s experiences of boredom, as well as their range of possible reactions. Different environments may thus elicit different types of boredom – with different consequences. And good choices require good options; the very environments that make boredom most likely may also be those least likely to afford positive solutions. Thus, in environments with impoverished options, boredom may cease to be a useful adaptive signal.

Different causes, different consequences. Different types of boredom confer different information – and may be accompanied by different consequences. For instance, boredom due to understimulation may encourage people to seek out interesting activities, while boredom due to overstimulation may encourage enjoyable activities instead. Interest requires cognitive resources to make sense of novel complex stimuli (Berlyne, 1971; Silvia, 2006); thus, interesting activities may be more appealing when people are bored due to understimulation, because such boredom informs people they have sufficient cognitive resources to experience interest. For instance, among 79 students assigned to an understimulating (vs overstimulating) version of a letter-detection task, participants who completed the easy version subsequently preferred to play an interesting game, whereas those assigned to the difficult version preferred an enjoyable one instead (Westgate, 2018). Thus, one simple reason for why boredom sometimes results in negative (versus positive) outcomes may simply be a function of the type of boredom experienced, and the information it provides.

Action over inaction. Emotions punish (and reward) behaviors. If boredom increases people's baseline preferences for action (over inaction), then inducing boredom experimentally should increase any action available. Overall, people prefer action over inaction (Albarracin et al., 2019); this tendency may be exaggerated when bored. Boredom increases novelty-seeking (Bench & Lench, 2019) and reward sensitivity (Milyavskaya et al., 2019). Thus, we predict that in situations that offer only a single available course of action, boredom will increase prosocial behavior if that available action is positive, but increase antisocial behavior if that action is negative (Yucel & Westgate, 2020). These results would account for previous findings that when only prosocial actions are available, people become more prosocial when bored, and that when only antisocial actions are available, people become more antisocial when bored. That is, previous findings may be a byproduct of experimental designs that confound prosociality/antisociality with action/inaction.

Choice availability. This general push towards action means that environments constrain people's ability to make good choices when bored. For instance, in experiments conducted by Pfattheicher et al. (2020), bored people tend to deduct rewards from other participants. However, when provided another option – boosting others' pay *or* deducting it, almost 90% of participants chose to boost others' pay, and boredom no longer predicted sadistic behavior among those low in trait sadism. Likewise, across 50 US states, regions lower in opportunity for meaning-making exhibited more boredom, as indexed by google search activities. And regional boredom, in turn, predicted problematic public health outcomes, even after controlling for overall well-being. This suggests not only that people are more likely to experience boredom in areas devoid of opportunity, but that lack of opportunity limits options that might enable people to escape from boredom, creating a vicious cycle.

For instance, a meta-analysis suggests a modest negative relationship between boredom and academic outcomes, $r = -.24$ (Tze et al., 2016). We argue that this relationship is due to teaching strategies that do not foster meaning and optimal attention, and students' lack of control and autonomy in responding to such environments. That is, with few opportunities to respond constructively to school boredom, students find other alternatives (such as bullying and antisocial behavior, e.g., Pfattheicher et al., 2021). For instance, compared to students who criticize the teacher or distract themselves to cope with boredom, students who reappraise the situation and augment the value of the current class were less frequently bored and fared more positively emotionally, motivationally, and cognitively (Nett et al., 2010).

Environmental mismatches. Malfunctioning adaptions, evolutionary conflicts, adaptively biased mechanisms, and other constraints on natural selection, may make behaviors and emotions that were once adaptive in the evolutionary past maladaptive in modern environments (Al-Shawaf et al., 2020). For instance, our predilection for high-sugar foods, once scarce and beneficial to survival, is less advantageous today when overconsumption of widely available sugar can contribute to the development of diabetes and other health risks (Symons, 1992). Such environmental mismatch between ancestral and modern society may alter the prevalence and form of the presence of boredom and also undermine the adaptive value of boredom in modern society. Technological progress in the form of automation has greatly increased productivity and safety, but has also been implicated in increasing boredom across a wide variety of professions, including air traffic control, firewatch teams, factory manufacturing (e.g., assembly lines), and anesthesiology. Likewise, new technology in the form of social media and cell phones offer easy and quick "solutions" to feelings of boredom (Kale, 2020). However, social media may not be the best solution to boredom in the long run and even lead to maladaptive outcomes (Elhai et al., 2017).

In a hunting-gathering society, humans live in groups and spend most of the time looking for food, so they don't have a lot of idle time to feel bored. But modern society is different. The development of agriculture and industry liberated us from heavy physical labor, and we live in a small family instead of large groups, so we have more leisure time and thus have more opportunity to feel bored. Also, think about meaning and attention, two components of boredom. In an ancestral setting, meaning for humans is just survival and reproduction. Our ancestors pay attention just to find food sources or to keep themselves from the attack of beasts. But the meaning has richer implications in modern society. We have other pursuits, like committed to advocating for minorities and building an egalitarian society, besides making a living, and thus we have to pay attention to a variety of tasks to pursue our goals, instead of approaching food and avoiding threats.

In summary, while boredom can lead to negative behaviors, it doesn't have to. The usefulness of boredom as a signal depends in part on the environment in which it is experienced. In environments with many good alternatives, boredom may be helpful in steering people towards better options; in contrast, in environments with limited options, or where a person's choices are highly constrained, boredom may cease to serve such adaptive functions. Limited autonomy may thus weaken interest and lead to boredom in situations that are already unpleasant to begin with (Deci & Ryan, 1985; Harackiewicz et al., 1987; Lepper & Greene, 1978). What people do about boredom thus depends on their own beliefs about its causes and benefits. In addition, while boredom may have been adaptive in our evolutionary past; however, not all such behaviors are necessarily adaptive today (Neuberg et al., 2010). We explore the consequences of this below.

Boredom Today

Emotions and behaviors may lose their adaptive value due to change in the environment, and formerly adaptive tendencies may (in the present context) actually lead to maladaptive outcomes. Although the word "boredom" has only existed in English for a little over 200 years (Merriam-Webster, 2020), its connotation has already changed considerably. In the Western world, "bore" [1768], the predecessor of boredom, referred to the act of being "tiresome or dull"; boredom appeared as early as the 1760s as an English expression to describe the supposedly "French" experience of having a dull time (Westgate & Steidle, 2020). This does not mean that people in the past did not feel bored; for instance, boredom appears in ancient Chinese poetry, largely in the context of leisure boredom. More recently, however, boredom has been deemed a problem of modernity, or even of technology.

Boredom and technology

Smartphones and other modern technology provide continual stimulation; social media, in particular, provides continually shifting variety (e.g., images, text, video) carefully calibrated to capture attention in short "chunks." For instance, Twitter imposes a 280-character limit on its posts and videos on TikTok (a video-sharing social media platform) average only 15 seconds. Most importantly, social media content is personalized via algorithms designed to retain users. Obviously, social media itself is not boring; it is specifically designed for optimal attentional engagement, stimulating users with a stream of familiar tropes punctuated by novel content, providing intermittent reinforcement for scrolling and refreshing.

For instance, TikTok downloads spiked during the beginning of the COVID-19 outbreak. Compared to the week prior to lockdown, UK TikTok downloads increased by 34% the week the lockdown was announced (Kale, 2020). Is this a bad thing? Several studies find that using smartphones as a strategy to reduce boredom ultimately results in many negative outcomes like anxiety and depression (Elhai et al., 2017). But not all studies paint a similarly bleak picture – for instance, although excessive use of smartphones and the internet was associated with anxiety and depression in a sample of 375 undergraduates, there was no relationship between these outcomes and using smartphones and the internet specifically as a method to reduce boredom (Panova & Lleras, 2015).

However, while social media may offer a temporary harbor from boredom, it may not be an effective long-term solution. Despite maximizing attention, technology varies considerably in the extent to which it aligns with valued goals – and thus, its meaningfulness. According to the *displacement-interference-complementary* framework of smartphone use (Kushlev & Leitao, 2020), for instance, smartphone use influences subjective well-being via three mechanisms – 1) replacing other activities, 2) interfering with concurrent activities, and 3) affording information and activities not otherwise available. The first two mechanisms negatively impact well-being by replacing (or interfering with) activities essential for well-being (i.e., via opportunity costs). Relying on smartphones can impair our social connection to the real world (Dwyer et al., 2017; Kushlev et al., 2017; Kushlev et al., 2019); and social media scrolling, especially, has been associated with decreased social connection and loneliness (Burke et al, 2010). A recent study (Allcott et al., 2020) found causal evidence for this link: paying people to deactivate their Facebook account for four weeks led to decreased political polarization and increased subjective well-being.

However, social media use can increase well-being when it complements real-world experience by offering information or access to activities one might not otherwise have. For instance, information-seeking on social media predicts meaningful engagement, while sociability does not (Leung, 2020). Likewise, active use (directly interacting with users on a platform) has been associated with increased subjective well-being, while passive use (i.e., observing but not interacting) has been associated with decreased subjective well-being (Verduyn et al., 2017). These findings echo our own predictions – when using social media to escape from boredom, meaningful use (i.e., active use, intentional information seeking) may decrease boredom, but meaningless use (i.e., aimless "doomscrolling") may be ineffective or even increase boredom.

Another concern is that social media and technology may make us more susceptible to boredom over time. In one news article from *the Guardian*, people complained that TikTok rendered them unable to engage in longer content, such as that offered on YouTube or Netflix (Haigney, 2020), and heavy smartphone users do report more severe attention problems (Hadar et al., 2017). Thus, one concern is that prolonged exposure to technology might result in cognitive and motivational changes that impair attentional capacity and hurt the ability to delay gratification. If TikTok rewards users every 15-30 seconds, users might become accustomed to this rate and shift their time discounting preferences from long-term to short-term rewards. Such short-term orientation has been implicated in many problems, including lower financial savings (Hershfield et al., 2009), more procrastination (O'Donoghue & Rabin, 2001), and general failure in goal pursuit.

In sum, more experimental research is needed to determine the causal relationship between boredom and technology (i.e., whether boredom makes us spend more time on smartphones or whether excessive smartphone use aggravates boredom, or both), and the outcome of boredom-driven smartphone use (i.e., whether it reduces vs amplifies boredom).

Socioecological views of boredom

Finally, we want to consider boredom in the context of modern socioecological structures, such as structural inequality. Experience sampling data suggests that boredom is higher among individuals with lower household income (Chin et al., 2017), and cross-national data suggests that boredom during the 2020 coronavirus pandemic was higher among countries with lower GDP, even after controlling for a host of other variables (Westgate et al., 2021). Likewise, boredom is quite common among people experiencing homelessness (Marshall et al., 2020), due to limited opportunity and financial ability to procure services and products to fill time with meaningful activities.

We predict boredom will be especially common in environmental contexts that are highly constrained, yet offer few outlets for meaning or optimal challenge. The U.S. prison system, for example, may be one such example. Boredom pervades the life of incarcerated youth (Bengtsson, 2012). Likewise, educational settings that stifle opportunities for meaningful challenge may foster boredom; classroom boredom has been associated with attentional problems and low intrinsic motivation (Pekrun et al., 2010).

We propose that policies, such as universal basic income and housing-first policies, that guarantee access to resources and opportunities may buffer against boredom and its associated societal costs. Likewise, reducing income inequality may offer an important path forward to reducing societal boredom, and can be addressed by resource reallocation policies such as progressive taxation. Research has shown progressive taxation to be positively associated with subjective well-being, largely because it reduces income inequality (Oishi et al., 2011; Oishi et al., 2018). Furthermore, having positive outlets available may reduce maladaptive responses to boredom and improve public health.

In short, boredom evolved to provide information about people's current motivational and cognitive capacities and to redirect them toward more meaningful or beneficial activities. However, that signal can go awry in the modern environment, when opportunities for meaningful optimal challenges are unavailable, or when competing outlets (e.g., social media) offer temporary solutions that feel good, but come at a long-term cost. Thus, shifting boredom in modern society may require shifting society itself to foster equity in opportunities for meaning-making and challenge.

Conclusion

Although boredom can produce maladaptive outcomes, it serves an important adaptive function in providing feedback about our behavior and environments, fostering exploration, minimizing opportunity costs, maximizing learning, and finally, reducing prediction error. Boredom signals that we are either unable or unwilling to continue our current activity successfully due to deficits in attention and/or meaning, and motivates us to change it. Although it may not feel good, we argue that the world would be worse without boredom. After all, without boredom, Zhao Shixiu might have waited forever (in vain) for his feckless friend to appear, and never have left his dark room to pen the poem he shared with us, and by extension, with you.

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