Beyond nature versus nurture: The emergence of emotion

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Abstract

Affective science is stuck in a version of the nature-versus-nurture debate, with theorists arguing whether emotions are evolved adaptations or psychological constructions. We do not see these as mutually exclusive options. Many adaptive behaviors that humans have evolved to be good at, such as walking, emerge during development–not according to a genetically dictated program, but through interactions between the affordances of the body, brain, and environment. We suggest emotions are the same. As developing humans acquire increasingly complex goals and learn optimal strategies for pursuing those goals, they are inevitably pulled to particular brain-body-behavior states that maximize outcomes and self-reinforce via positive feedback loops. We call these recurring, self-organized states *emotions*. Emotions display many of the hallmark features of self-organized attractor states, such as hysteresis (prior events influence the current state), degeneracy (many configurations of the underlying variables can produce the same global state), and stability. Because most bodily, neural, and environmental affordances are shared by all humans–we all have cardiovascular systems, cerebral cortices, and caregivers who raised us–similar emotion states emerge in all of us. This perspective helps reconcile ideas that, at first glance, seem contradictory, such as emotion universality and neural degeneracy.

Beyond nature versus nurture: The emergence of emotion

For over 100 years psychologists have debated whether emotions are more like soldered circuits whose designs are encoded in our genes, or more like software programs written by context and experience—whether, in the language of bygone debates within biology, emotions reflect nature or nurture. Most attempts to reconcile the two perspectives involve a compromise in which nurture modifies the innate emotion programs given to humans by nature (i.e., by our genes; Mesquita & Walker, 2003; Matsumoto & Hwang, 2012; Levenson et al., 2007; Oatley, Keltner, & Jenkins, 2006). But this compromise still implies that we can meaningfully differentiate what humans are "born with" from what happens to their bodies as they interact with their environment, and indeed that doing so is of vital scientific importance.

Contemporary evolutionary biology has largely moved on from the nature-nurture debate, as accumulating theory and evidence complicates the boundary between phylogeny and ontogeny (Hochman, 2013). We see the future of affective science as one that has caught up to modern biology by no longer considering evolution and development, or, as some would have it, adaptive specificity and mechanistic degeneracy (Edelman and Gally, 2001), as competing explanations (Bergman & Beehner, 2022). From here, we propose that at the level of goal-directed behavior, emotions are relatively universal, discrete, and adaptive—one might say *evolved*— but also *necessarily* constructed through the body's interaction with the environment.

Adaptive traits primarily manifest as the organism interacts with, and develops within, its environment (Feigin et al., 2022; Gomez-Marin & Ghazanfar, 2019). As an analogy, consider bipedal walking. From our heads to our toes, evolution has shaped our musculoskeletal system to suit this behavior. Our bodies have evolved to walk. But nothing coded in our DNA "tells" us to walk. So why do all able-bodied adults walk in similar ways? Because the form of our bodies and the combination of affordances (i.e., opportunities for action) and demands in our environments combine with our motivation to move. As our bodies develop, we dynamically fumble our way towards an efficient gait (Adolph et al., 2012), with the help of a bit of behavioral transmission from observing nearby adults (Berger et al., 2007). Even a computer-simulated pair of legs can learn to walk, so long as its “goal” is to travel as efficiently as possible (e.g., Reil & Husbands, 2002). Any slight variability in how people walk occurs because bodies vary and gaits are, to a small degree, culturally transmitted (Wallace et al., 2022).

Importantly, walking manifests differently in different contexts (Gates et al, 2012). Walking on level ground with sufficient traction selects for a gait and pace that most people, regardless of culture or other individual differences, will move toward. Call this “Gait 1.” By contrast, walking in deep sand demands relative decreases in plantar flexion and hip extension, with increases in knee angle flexion, in order to optimize stability and efficiency (Lehmann & Artemiadis, 2020). Call this “Gait 2.” Again, most people will, regardless of culture or other individual differences, move from Gait 1 to Gait 2 when moving from a stable, flat surface to a sandy one. “Gait 3”—which manifests as shorter and more frequent steps—optimizes walking on ice (Fossum, Hillnhütter, & Ryeng, 2022). “Gait 4” dramatically increases forward lean when carrying a heavy backpack (Attwells et al., 2006).

Here, we suggest that different emotions are like different gaits in the examples above—optimal, perhaps, for relatively specific conditions.[1] Fear may not be specifically controlled by phylogenetically determined genes and circuits, but humans are nevertheless animals that

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[1] Note we are *not* saying that emotions are optimized for specific "situations” (e.g, being on a roller coaster or being chased by a bear) since appealing to situations may neglect attention to the sensory properties (the sensation of speed, the sound of a growl) and contextual demands (the need to flee) that actually mediate emotion attractors. “Situations” can likely act as proxy variables for the sensory properties and contextual demands of interest, but as a practical matter, maintaining focus on those properties and demands should facilitate the standardization of elicitation and assessment approaches (cf., Coan & Allen, 2007).

commonly respond to things with fear, because they commonly encounter things requiring coordinated responses that can profitably be categorized under the term “fear.” Framing humans as complex dynamical systems (an idea we explain in the next section), fear could be an attractor state that all or most humans (re)discover as their embodied brains encounter threats in the environment (Scherer, 2009), learn how to escape those threats, and track their goal progress (Cunningham et al., 2013; Lowe & Ziemke, 2011). We call these self-organized goal states and their associated responses *emotions* (Adolphs & Anderson, 2018).

Distinct emotions are emergent states

A person is a complex dynamical system made of a huge number of interacting processes: 11 major organ systems, over 50 hormones, over 100 neurotransmitters, 86 billion neurons, and over 600 muscles. And the components interact not just with each other, but also with the environment and the many other dynamic systems (e.g., people) in that environment. When the components of a system interact, surprising patterns of behavior often emerge. These *emergent processes* are difficult or impossible to predict by observing the behavior of individual components (Nicolis & Nicolis, 2012). Even knowing the simple rules guiding how an ant interacts with its environment, you would probably not predict that when many army ants are together, they can use their bodies to form gravity-defying bridges that other ants can then use to cross obstacles (Reid et al., 2015). A defining feature of emergent processes is that there is no central controller, no ant architect directing the other ants. Similarly, we argue emotions are not turned on and off by a central controller, be it a subcortical nucleus in the brain, a particular neurotransmitter, or the activation of a concept.

The attractors that we recognize as common human emotions—anger, sadness, amusement, dread, love, and so on—are not pre-formed upon our entry into the world. As water flowing downhill gradually carves the land, leading even more water to follow the gully's path, emotions are carved as we discover and repeat the behaviors (and the supporting neural and bodily states) that help us achieve our goals (Moors & Fischer, 2018). Research with robots illustrates the remarkably complex behaviors that can emerge when an organism with simple goals (e.g., to learn) and a specific body interacts with its environment (Gordon, 2019; Barrett, 2011). Without being programmed to do so, robots can play (Oudeyer & Smith, 2016), cry for attention (Gordon & Breazeal, 2014), and walk (the latter is accomplished without a "brain" at all; Collins et al., 2005).

The emotional life of a newborn baby might best be described as a bistable system, the simplest multiple attractor system (Kelso, 2012): newborns are either fussy or content (Reissland et al., 2013). But as the child's behavioral repertoire expands and they bootstrap more complex goals, new emotion attractor basins form (Bennett et al., 2005). The emotion landscape also becomes increasingly stable over the course of childhood and adolescence (Reitsema et al., 2022). This stabilization is accompanied, but not necessarily caused by, an expanding emotion vocabulary (Nook & Somerville, 2019). Many developmental paths can lead to the same attractor landscape as each developing human discovers the optimal solutions to common goal-relevant challenges.

We are not the first to call emotions emergent processes (e.g., Coan, 2010; Barrett, 2014; Lindquist, 2013; Cunningham et al., 2013; Clore & Ortony, 2013; Witherington & Crichton, 2007; for a similar argument about emotion displays, see Fridlund, 2014). Indeed, empirical work shows that dynamical systems models, such as a modified Ising model (Loossens et al., 2020) and coupled oscillator models (e.g., Boyd et al., 2022; Chow et al., 2005) are useful for describing affective dynamics. We differ from prior perspectives in at least two ways: first, we do not consider emotion concepts necessary for the emergence of an emotion (in contrast with Barrett, 2014; Lindquist, 2013; Cunningham et al., 2013; Russell, 2003). Although activating an emotion concept can alter the trajectory of an emotion state (Torre & Lieberman, 2018; Wood et al., 2016), stable and specific emotion states emerge because emotion states are self-reinforcing.

This brings us to a second way in which we differ from prior "emergent emotion" perspectives (c.f., Scherer, 1994; Witherington & Crichton, 2007): we emphasize the way in which global *stability and order* self-organize around higher-probability situational demands and opportunities (Camazine et al., 2020). Organisms can theoretically exist anywhere in a high-dimensional space that includes many possible combinations of brain, bodily, subjective, and behavioral states.[2] But organisms do not in fact occupy all corners of this massive *state space* at the same frequency (Cowen et al., 2019; Kelso, 2012). Some states, called *attractor basins*, are more stable, and thus visited more frequently, than others (see Figure 1). A person in a less stable transitional state will be pulled to the nearest attractor basin. Environmental, bodily, and/or neural processes reinforce each other, and create positive feedback loops that result in emotional attractor states (e.g., Hoeksma et al., 2007; Cunningham et al., 2013; for a similar argument about psychiatric disorders as attractors, see Rolls, 2021). Some emotion states become stable attractors because they are rewarded—they serve specific goals and transform into habits (Wang et al., 2021). We reason that some states (such as fear) are equally attractive across individuals because they solve common goal-relevant environmental problems using common affordances that result from the body-environment interaction. This is analogous to *fitness landscapes* in evolutionary biology: organisms do not take all possible forms, instead converging to certain

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[2] This is the point at which, for example, Coan (2010) leaves off in his discussion of the statistical properties of emergence.

adaptive forms that are stable because all immediately surrounding states are less adaptive (de Visser & Krug, 2014).

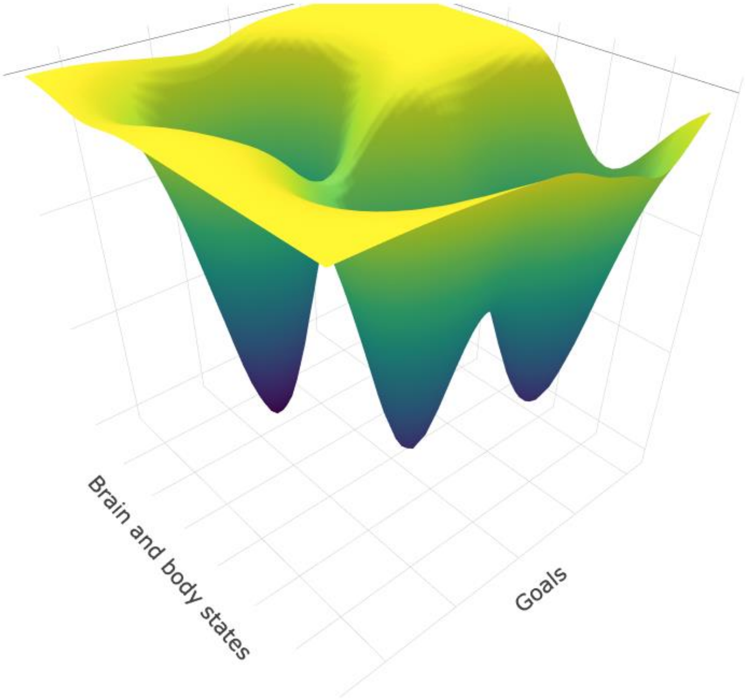

Figure 1. At any moment, a person has goal(s) and is in a particular brain-body state. Here we visualize this as a 2-dimensional space (x-y plane), but of course it is a very high-dimensional space with all dimensions of neural activity, physiological activity, behavior, and cognition. The z dimension represents the stability or attractive force of all possible locations in this high-dimensional space. Some locations–attractor basins, in blue–become more attractive and stable through development and reinforcement. If a person is in a nearby, but less stable state, they will be pulled toward these more attractive states like a ball rolling downhill. We call these emotion states discrete because the phase transitions between them are nonlinear (rather than gradual and linear; Korolkova, 2018).

An organism moves from one attractor basin to another following changes in the key variables sustaining the state. These changes are often achieved through the very behavior motivated by the emotion. For instance, running away from a threat during a fear state changes the perception of the environment from unsafe to safe, which will pull the organism to a state of calm. We can map the system's likeliest trajectories through the state space (Thornton & Tamir, 2017).

Although people (Kuppens & Tong, 2010) and cultures (Lindquist et al., 2022) vary in the emotions they display and experience, some aspects are more or less universal (e.g., Cowen & Keltner, 2020; Jack et al., 2016). Human environments share many common affordances and demands (other people, threats, food, hunger, reward, possessions, and so on). Human bodies and brains offer a finite number of possible responses to these affordances and demands, and some of these responses will more objectively optimize outcomes (Davies et al., 2012). We suggest that these optimal solutions can and do lead to the emergence of similar emotion attractors across people and cultures (psychopathology aside) by the same process and for the same reason that stereotyped human gaits emerge from interaction with different walking surfaces in our earlier example. Our commonalities, combined with non-genetic processes of inheritance such as social learning and cultural evolution (Heyes, 2018; Lindquist et al., 2022), means that our genes never had to bother with encoding discrete emotion states (Clark, 1989, p. 64), just as they never had to bother with encoding discrete walking gaits.

One feature of attractors that we see in emotions is *hysteresis*: leaving an attractor basin requires a stronger input than entering it, just as a hill requires more effort to climb than to tumble down. Emotions are likewise characterized by their persistence, lingering even after the eliciting stimulus is removed and having slower offsets than onsets (Hoeksma et al., 2007; Schuyler et al., 2014). We expect the depth and steepness of attractor basins to vary within and across people, meaning some emotions will have stronger "gravitational" forces than others. Following the principle of hysteresis, these deeper and steeper basins might simultaneously have faster onsets and slower offsets. This leads to the prediction that onset and offset time should be negatively correlated across emotions and individuals.

At lower levels of analysis (e.g., central or peripheral neural systems), emotions also display *degeneracy* (Lindquist et al., 2016). Degeneracy means many underlying patterns of neural or physiological activity can produce the same stable emotion state and functional outcome, in a many-to-one mapping (Kelso, 2012). Of course, scientists can predict a person's emotions often well above chance based on their neural or physiological response profile (e.g., Kolodyazhniy et al., 2011), but the response profiles are only probabilistically associated with specific emotions. Degeneracy is a feature of complex dynamical systems and contributes to the diversity and stability of the attractors, as synergistic processes compensate for perturbations to any one part (Kelso, 2012; Whitacre, 2010). Degeneracy does *not* mean the emergent emotion is wholly unique and context-specific (cf. Barrett, 2017). Rather, neural and physiological degeneracy underlies globally consistent consequences, such as repeated and recognizable feelings, goal-directed behaviors (Lowe & Ziemke, 2011), and reliable consequences (Coan, 2010). These consistent features of emotions help us survive, whether through aggression or nurturing or escape behaviors, and make the outcomes of our behavior more predictable and adaptive. Systems that exhibit degeneracy are also flexible and better at exploring state space for more optimal solutions (Komar et al., 2015).

Because the individual components of an emotion display degeneracy, we identify and categorize emotions at the more abstracted level of *goals* (Moors & Fischer, 2018). We cannot classify a person's emotion state based on their physiological profile, facial expression, or brain activity, because many patterns give rise to the same emergent emotion. When qualitatively distinct states emerge from the interaction of individual components, but the exact behavior of any one component does not decide the fate of the whole, it is no longer useful to categorize those states at the level of the components. This goal-centric view is compatible with some appraisal theories of emotion (e.g., Scherer & Moors, 2019), and with more recent characterizations of emotions as tracking progress towards (or away from) goals (Cunningham et al., 2013; Kron & Weksler, 2022).

Emotions are not reflexes that take a rigid, stereotyped form (like a sneeze). They are more flexible and context-dependent, and this makes them useful (Adolphs & Anderson, 2018). People flexibly experience familiar emotions (fear) in response to novel experiences (being stalked by a zombie). And familiar emotions can flexibly lead to novel behavioral solutions (setting up a zombie booby trap), as long as the behavior is predicted to produce a desired outcome (trapping said zombie). Successful high-level behaviors are reinforced and become likelier in the future. Rather than having to stumble upon a novel behavioral response each time a goal is at stake, organisms have organized, repeatable emotion attractor states that, when they enter them, make previously-successful behavior patterns salient and likelier (although still constrained by the affordances of the environment). Commonalities across people's goals, bodies, and environments mean that there are recognizable *action tendencies* loosely associated with particular emotions, which observers can use as cues to infer the actor's underlying emotion.

A particular subcategory of emotion-related behaviors–signals like facial expressions and vocalizations–demonstrate why stable and repeated emotion behaviors are adaptive. Signals like smiles, scowls, and screams do not function as readouts of emotion states; instead they function to influence the receiver (Crivelli & Fridlund, 2018), often by conveying information about the sender's intentions. Signals that are entirely ad hoc will not have a predictable effect on receivers, rendering them functionless (Bradbury & Vehrencamp, 2000; cf. Barrett, Lindquist, & Gendron, 2007). But how do recognizable emotion displays emerge again and again across individuals, cultures, and species? Smiles, at first glance, may seem like arbitrary signals given meaning by either genes or culture. But smiles alter the vocal tract, ever so slightly, making the producer's body sound smaller than it is (e.g., Lasarcyk & Trouvain, 2008). Across the animal kingdom, signals of *smallness* are also signals of *nonthreat*–not because our genes tell us so, but because we learn that small things are statistically less likely to present a threat. Given this fact, individuals can learn through reinforcement and social imitation to change their mouth shape in order to convey friendliness. We suspect this sort of form-from-function reasoning, combined with an emergent developmental story, could go a long way in explaining universal communicative signals (e.g., Wood, et al., 2017; Chuenwattanapranithi, et al., 2009; Fridlund, 2014).

An example: The emergence of *fear*

To illustrate our view of emotions as being both emergent and evolved, let us return to the emotion *fear*. Newborn infants do not exhibit fear (Debiec & Sullivan, 2017). Fear is about the anticipation of potential threats, and newborns do not have sufficient prior experience on which to base predictions of future threats (LoBue & Adolph; 2019; Adolph et al., 2014). Moreover, escaping from a threat is not a behavioral affordance that is available to a helpless newborn, so a state that motivates such behavior would be useless.[3]

The complex system that is a newborn infant has one "goal": to predictively adjust their internal physiology in the service of survival, a process known as *allostasis* (Sterling, 2012).[4]

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[3] Infants have protective reflexes like the Moro reflex, which they display when dropped, but this requires only the presence of a brainstem and does not necessarily involve an organized fear state (Futagi et al., 2012).

[4] Allostasis—stability through change—is Sterling and Eyer's (1988) theoretical elaboration on *homeostasis*. Whereas homeostasis refers to an organism's tendency to return to a preferred physiological attractor state, allostasis instead emphasizes the optimization of the organism's response to variable environmental demands with the predictive regulation of the body's highly adaptive physiological and behavioral systems. In homeostasis, the organism is always seeking a

The newborn's allostatic solution, which is to say the most efficient and effective solution, to most threats–hunger, exhaustion, heat, cold, gassiness–is to fuss and recruit a caregiver's help. Over development, the infant learns how to predict upcoming threats ("going to this place called the pediatrician means painful needles!") and organizes behavioral responses to evade those threats (throw a fit!). As the child expands their behavioral repertoire, they discover that some responses are more efficient and effective for addressing some kinds of threats than others. For instance, freezing is useful for uncertain threats, such as when a stranger tries to talk to you. These reinforced responses are carved into their behavioral state space as attractor basins that pull at the system when it is in nearby states–if they encounter stimuli previously associated with danger, if their physiological arousal spikes, or if they think about something scary, they are more likely to fall into the fear attractor state. Many initial conditions lead to the state of *wanting to evade a threat* (fear), and once they are in that state, they will be slow to leave it.

Animal and human research suggests that organisms flexibly shift their likely behavioral responses depending on the imminence of a threat: a psychologically distant threat increases vigilance, but as it nears, vigilance becomes freezing, then attempts to escape, then defensive aggression (Hoffman et al., 2022). The exact actions required for the response will vary from situation to situation, so many underlying neural and physiological configurations lead to similar stable states (Barrett & Finlay, 2018). The qualitatively unique states that emerge, such as vigilance and escape behavior, may represent distinct attractor states, so it may be most useful to call them separate emotion states, such as anxiety, fear, and panic (Adolphs & Andler, 2018; Fanselow, 2022).

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particular physiological state. In allostasis, the organism is always seeking the most efficient and effective physiological state given prevailing circumstances.

These responses (freeze, flee, fight) are universal and re-emerge even across species without necessarily being hard-wired. Yet the specifics of the body *and* the environment are central determinants of which solutions are optimal–a tortoise's shell and slow speed make its go-to solution freezing. A dog on a leash (an environmental constraint) will often immediately resort to aggression regardless of threat imminence because freezing and escape are no longer options (a phenomenon known as leash aggression).

Evolution and emergence: Two sides of the same coin

Although we have argued that stable emotion states emerge as the organism interacts with the environment, we cannot ignore evolution. The ability to walk bipedally emerges through trial-and-error learning, and yet biological evolution (which includes but is not limited to genetic variation; Jablonka & Lamb, 2014) has shaped our bodies for bipedalism. And however learning to walk bipedally has evolved and developed, it is unlikely that any of the gaits in our earlier example have an exclusive genetic or neural provenance; each gait is simply the best solution for safely traversing a specific surface. Likewise, specific emotion states may emerge and stabilize as attractors through experience with the world, but biological evolution nevertheless bequeathed us the machinery with which to generate those attractors. Our ability to communicate emotion states is enhanced by well-differentiated facial muscles that anchor to our skin so each muscle contraction is maximally visible to others (Burrows, 2008). Our brains allow us to learn, remember, and predict the best possible behavioral paths for achieving necessary goals, and our ability to generalize allows us to use organized emotion responses in new contexts.

Complex behavior can emerge from the interaction of simple neural systems, environmental affordances, and specialized bodies shaped by evolution. As an analogy, consider how female crickets find, and mate with, males who produce the loudest version of a species-specific mating song (example borrowed from Barrett, 2011). The females' apparent ability to listen to enough of a song to recognize it, compare it to others and decide which is loudest, and then locate her chosen mate, suggest she is remembering, recognizing patterns, deciding, and planning a route. But she is not. Rather, this complex behavior all results from her ear anatomy. When sound reaches her eardrums, two neurons cause her to turn in the direction of the eardrum that received the sound first (and is therefore closer to the source). This happens over and over, slowly drawing her towards her future mate; louder chirps activate the neurons more strongly, overriding the possibility that she move towards quieter chirps. But how does she differentiate her species' mating call from other species'? First, her tracheal tubes, through which the sound travels, have evolved to resonate at the specific frequency of her species' chirps. Second, the males' chirp syllables are timed to the decay rate of her neurons to maximize neuronal firing and sustain her movement towards the male. Syllables that are too close or too far apart will cause the cells to fire less, making her drift off course as she tries to follow the sound of the wrong species.

Humans are not crickets, and our brains are vastly more complex. But this detour into cricket anatomy demonstrates how evolution and the emergence of complex phenomena–including, perhaps, emotions–work together. Female crickets did not evolve mating ritual brain circuits. Instead, they evolved bodies and simple neural systems that, through interaction with an "expected" environment (one with crooning males within earshot), produce adaptive, specific behaviors. Likewise, to experience discrete states like love, anger, sadness, or fear, humans did not need to evolve specific emotional capacities. We needed to evolve bodies with more domain-general features, like responsive autonomic nervous systems, hormones that diffuse widely, a musculoskeletal system that can act, and brains that can encode and integrate information and direct behavior in the service of goals. We would not have sadness without the capacity to remember what we have lost. We would not have fear if we could not feel pain or discomfort. We would not have anger if we had no way to respond to frustration. The human body takes its form for many reasons, and one of them may be that it supports the emergence of adaptive emotion states.

Emotions, in turn, likely scaffolded the biological and cultural evolution of other mammalian and human traits. We propose that stable emotion states, which emerged as each individual interacted with their social and nonsocial environment, expanded the possibilities for biological and cultural evolution. For instance, love and separation distress are the glue that bind families and social groups, without which our species would not survive (Beckes & Coan, 2011).

A modern affective science

We have presented a framework of emotions as emergent states that is compatible with the *ecological dynamics framework* (Seifert et al., 2016), which combines ecological psychology's emphasis on the body and environment with complex dynamical systems reasoning. Our perspective is also in the spirit of Witherington and Crichton (2007), who argue for blending dynamical systems and functionalist emotion views as complementary levels of explanation.

Future work should continue to test the fit of dynamical systems models to densely-sampled dynamic emotion data (e.g., Boker, 2002; Hoeksma et al., 2007; Butler, 2017; Chow et al., 2005; Pettersson et al., 2013). An exciting direction is to computationally model the emergence of specific goals (such as the goal to be with others, Atzil et al., 2018) and the optimization of behavior that serves those goals (e.g., FeldmanHall & Chang, 2018; Pacella et al., 2017). Critics of the notion that emotions are stable states may instead model emotions as *flow-type attractors* (Shibata & Goto, 2017). Beyond relying on longitudinal data, affective scientists could borrow biological approaches for modeling fitness landscapes to identify emotion attractor basins (for a similar approach to cultural evolution of religions, see Poulsen & DeDeo, 2023).

Testable hypotheses follow from the assumption that emotions are emergent attractors. For example, over development, we expect a few stable states to bifurcate and multiply, which fits with existing evidence that emotion knowledge becomes increasingly granular during development (e.g., Nook & Somerville, 2019). But individuals may not follow the same developmental trajectory, even if they converge to similar emotion landscapes. Another predicted consequence of emotional maturity is that emotion states will be increasingly contingent on the environment; domain experts, such as professional athletes, are more attuned and responsive to environmental affordances, producing more goal-relevant outcomes (Seifert et al., 2016). A child's behavioral solution in all negative states may be to throw a tantrum, while an adult's response may (hopefully) be more goal-directed and contingent on the context, reflecting their emotional "expertise." We might also hypothesize that emotions that are distant from all other emotions (e.g., lust) will be more stable, whereas emotions that are more proximal to each other (e.g., fear and disgust; Cowen & Keltner, 2017) will more easily destabilize each other. Another prediction is that a system can be pushed out of a habituated attractor state (e.g., fearful or sad rumination) through an *unrelated* perturbation (e.g., a random distraction; Huffziger & Kuehner, 2009). Of course, there are many more possibilities. By viewing emotions as emergent attractor states, we can shift our focus toward the functional coupling of individuals to their environments in ways that offer relief from spurious disagreements about nature versus nurture.

In sum, we have sketched a perspective of *where emotions come from* that combines basic emotion theories' emphasis on adaptive functions and universality with psychological constructionism's emphasis on context-dependent learning. Our disagreement with standard basic emotion theories is where the information that gives rise to discrete emotions is encoded: rather than being encoded in genes that give rise to specialized emotion-generating brain systems (e.g., Pacella et al., 2017; Gu et al., 2019), we see emotions as arising from the body's response to the sensory properties and demands of the environment. Our disagreement with psychological constructionism is about the end product of degeneracy and learning: rather than the end product being core affect layered with culturally-specific, ad hoc emotion concepts (Barrett, 2014; Lindquist, 2013), we see the end product as being distinguishable emotion states.[5]

All organisms attempt to optimize their behavior to maximize reward and minimize cost as cheaply and efficiently as possible. Emotions are practiced feeling-behavior patterns that the organism discovers and employs as efficient means for achieving goals. The specific goals–to be near others, to mate, to play, to be safe–are bootstrapped from the most basic goal of predictively regulating and maintaining the body (Sterling, 2012). Given nothing more than that imperative, a sufficiently resourced environment, and time, most humans will discover stable (and, to some degree, similar) emotion attractors that capitalize on the affordances of the body and environment. We call for affective scientists to follow the path of contemporary evolutionary biologists (Jablonka & Lamb, 2014; Keller, 2010) and recognize that nature and nurture are two sides of the same coin.

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[5] Distinguishable when identified at the level of functional goal pursuit, not at the level of individual components, because complex systems display degeneracy.

Conflict of interest statement

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Authors contributions statement

A.W. and J.C. wrote the manuscript.

Data availability statement

No new data were created or analyzed in this study. Data sharing is not applicable to this article.

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