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Evolutionary Psychology and Emotions: A Species-Typical Computational Design

Abstract. Evolutionary psychology is a major naturalistic approach to knowledge. It begins from a fundamental observation: the human brain is the product of natural selection trying to solve adaptive problems faced by our hunter-gatherer ancestors. In this paper, I describe this approach and focus on the emotions, an important aspect of mental life. Emotions, I argue, are a superordinate program that evolved to coordinate the activity of other programs in the solution of typical adaptive problems.

Keywords: evolutionary psychology; mind; emotions; natural selection; superordinate program; cognition.

Introduction

The aim of this essay is twofold: to describe evolutionary psychology (EP), one of the main naturalistic approaches to knowledge in today's cultural panorama, and to examine the emotions as an applicative field of EP. EP is an ambitious research program (Symons, 1987; Cosmides & Tooby, 1992; Tooby & Cosmides, 1992; Buss, 1995; Pinker, 1997; Adenzato & Meini, 2006; Bruni, 2017) aimed at contributing to the naturalization of the human sciences. According to EP, human cognitive architecture can be understood using the principles of evolutionary biology. All our natural capacities—language, vision, sexual attraction, fear, aggression, moral judgments—are possible thanks to a complex information system produced by natural

selection, that is, the human brain. Identifying natural selection as a unifying empirical and theoretical construct of the human sciences, EP turns its attention to the brain as a biological system responsible for heterogeneous cognitive skills and tries to furnish models for these skills' functioning and phylogenetic history. In this view, the identification of selective pressures and, therefore, of adaptive problems can help explain a given cognitive process and help identify its neural basis.

It was the English naturalist Charles Darwin himself, the developer of natural selection, who first showed how his theory might be used to understand the phylogenesis of human cognitive architecture. Natural selection principally addresses changes in the morphology of living beings. According to this theory, the form and consequent possible functions of organisms result from long environmental pressures and mutations. But Darwin already supposed that his "mechanism" could not only influence morphological change, but also affect psychological modifications in living beings.

A Remarkable Prophecy of Darwin

In the concluding chapter of the *Origin of Species*, Darwin (1859) writes:

> In the distant future I see open fields for far more important researches. Psychology will be based on a new foundation, that of the necessary acquirement of each mental power and capacity by gradation. Light will be thrown on the origin of man and his history. (p. 448)

Psychology, Darwin claims, will acquire a new foundation based on the theory of natural selection. If our cognitive abilities evolved in the same way that morphological characteristics like bipedal gait and posture did, then they are likewise subject to natural selection's laws. Darwin's move is revolutionary from a theoretical perspective. In all his works, Darwin argues that the theory of natural selection is about morphological change. The hypothesis that this theory also regulates the change of functions related to morphology is somehow surprising. It is an embryonic attempt to capture the least palpable part of human nature.

This attempt is evident in *The Expression of the Emotions in Man and Animals* (Darwin, 1872). Here Darwin applies natural selection to the primary system of animal communication, i.e., the emotions. These are useful

for manifesting mental states like joy, anger, and fear. Moreover, they are specialized behavioral-response structures that are indispensable for survival and represent an element of continuity between human and non-human animals. In humans, they are at once bodily, social, and cultural phenomena. While these points are discussed in detail in the following paragraphs, let us first return to the Darwinian prophecy.

The psychologist Leda Cosmides and the anthropologist John Tooby took Darwin's words to heart and founded a research program with the goal of keeping together psychology and evolutionism. For Cosmides and Tooby (1992; Tooby & Cosmides, 1992), our mind is an adaptation shaped by natural selection to our ancestral environment. An *adaptation* is an anatomical character, biochemical property, skill, or behavior that may have been selected in a certain environment by increasing an organism's probability of survival or reproduction (Williams, 1966). According to Cosmides and Tooby (1992):

> The human mind is the most complex natural phenomenon humans have yet encountered, and Darwin's gift to those who wish to understand it is a knowledge of the process that created it and gave it its distinctive organization: evolution. Because we know that the human mind is the product of the evolutionary process, we know something vitally illuminating: that, aside from those properties acquired by chance, the mind consists of a set of adaptations, designed to solve the long-standing adaptive problems humans encountered as hunter-gatherers. Such a view is uncontroversial to most behavioral scientists when applied to topics such as vision or balance. Yet adaptationist approaches to human psychology are considered radical--or even transparently false-when applied to most other areas of human thought and action, especially social behavior. Nevertheless, the logic of the adaptationist position is completely general, and a dispassionate evaluation of its implications leads to the expectation that humans should have evolved a constellation of cognitive adaptations to social life. Our ancestors have been members of social groups and engaging in social interactions for millions and probably tens of millions of years. To behave adaptively, they not only needed to construct a spatial map of the objects disclosed to them by their retinas, but a social map of the persons, relationships, motives, interactions, emotions, and intentions that made up their social world. (p. 163)

Human beings, Cosmides and Tooby contend, are endowed with a special faculty for social cognition. This consists of a rich collection

of input-processing systems, or *modules* (Fodor, 1983), that are functionally specialized and aimed at guiding thought and behavior toward the solution of recurrent adaptive problems posed by the social world (Pinker, 1997). These problems include the search for food, defense from predators, resistance to infection, the choice of suitable coupling partners, the feeding of offspring, and the ability to understand and predict the actions of others and manage family relationships (Buss, 2012; Cosmides & Tooby, 1995). They are known as "selective pressures." In this framework, the modern human mind is the result of a long evolutionary history characterized by selective pressures and adjustments.

Each mental module is an adaptation in response to inputs from the Environment of Evolutionary Adaptedness (EEA). The EEA, within which the development of the mind took place, is not made up of spatio-temporal coordinates. The notion of the EEA was introduced by John Bowlby (1969) in his theory of attachment. By this expression Bowlby refers to the idea that the natural circumstances in which an organism or species evolved determine its behavioral manifestations. This definition has become a central aspect of EP. As Cosmides and Tooby (1990) stress:

> The "environment of evolutionary adaptedness" (EEA) is not a place or a habitat, or even a time period. Rather, it is a statistical composite of the adaptation-relevant properties of the ancestral environments encountered by members of ancestral populations, weighted by their frequency and fitness-consequences. These properties are selected out of all possible environmental properties as those that actually interacted with the existing design of the organism during the period of evolution. (pp. 386–7)

Each species has its own EEA. The human EEA coincides with the Pleistocene, the geological era that began 2.6 million years ago, ended eleven thousand years ago, and corresponds to the end of the last glaciation. During this period, the members of genus *Homo* lived in small groups of hunter-gatherers. This type of social organization survived until relatively recently. It changed with the birth of agriculture and livestock care that radically altered human's relationship to the environment. From this moment forward, human groups become numerous and the first urban centers take shape. These changes have been fast on the natural-historical timescale. But this speed conflicts with processes underlying human evolution, which are slow and gradual. The time in which genetic mutations occurred through significant changes in our cognitive architecture is, in fact, a deep time that has acted

slowly over thousands of generations. The direct consequence of this reasoning is that the past five thousand years, the time separating us from the birth of farming and the beginning of modern social organization, is too short for any fundamental change in our psychological mechanisms. This is the reason why evolutionary psychologists believe that in order to understand the reasons behind psychological adaptation, it is necessary to understand the selective pressures that characterized the EEA of the Pleistocene. Observable behaviors that can be considered adaptations of this type include particular reproductive modalities or manifestations of aggression and defense. This means that every behavior was produced by selection because, in a given situation, it was more effective than possible alternatives (Symons, 1992). All the psychological processes that characterize the human mind provided an evolutionary advantage for our ancestors. The existence of this advantage would explain the current presence of such brain structures and functions as the discovery of cheaters and self-defense from aggression and unforeseen events.

Natural selection therefore becomes a powerful theoretical tool for explaining what makes us human—our capacity for perception, actions, language, thought, and emotions.

The Three Levels of Explanation of EP

Between roughly 1920 and 1960, an empiricist approach to cognition dominated psychology. Behaviorism and constructivism were the two prevalent conceptions (Watson, 1913; Skinner, 1957). According to these, all human beings at the birth are characterized by an extremely poor mind, a sort of *tabula rasa*. The environment and external stimuli to which the subject is exposed entirely determine the content of her/his learning. The mind's content, a set of cognitive faculties, depends on the experiences the subject has lived. It is free from biological influences, shaped exclusively by environmental, historical, and cultural factors. Tooby e Cosmides (1992) define this theoretical framework, which is typical of the social and behavioral sciences and precedes the birth of EP, as the *Standard Social Science Model* (SSSM). The SSSM is characterized by a domain-general mental architecture:

> According to this view, all of the specific content of the human mind originally derives from the "outside" – from the environment and the social world – and the evolved architecture of the mind consists

> solely or predominantly of a small number of general purpose mechanisms that are *content-independent*, and which sail under names such as "learning", "induction", "intelligence", "imitation", "rationality" "the capacity for culture" or simply "culture". On this view, the same mechanisms are thought to govern how one acquires a language and how one acquires a gender identity. identity. This is because the mechanisms that govern reasoning, learning, and memory are assumed to operate uniformly across all domains: They do not impart content, they are not imbued with content, and they have no features specialized for processing particular kinds of content. [For this reason, they are described as *content-independent* or *domain-general.*] (Cosmides & Tooby, 1992, pp. 164–165)

Since the end of the 1950s, the theoretical climate has changed profoundly. It has been defined the so-called "cognitive turn," i.e., the end of behaviorism and the emergences of cognitive psychology. This cognitive revolution was characterized by Noam Chomsky's nativist theory of language (Chomsky, 1959), a renewed vigor of Darwinian perspective (Tinbergen, 1951; Williams, 1966), and Hilary Putnam (1967) and Jerry Fodor's (1975) functionalism. The idea that both natural and biological factors influence our social and individual behavior has come to the fore.

The cognitive turn showed that the SSS model of general-domain intelligence fails to reflect the way the mind works. Social factors are not autonomous from biological and psychological factors. The mind is characterized by a set of innate cognitive modules, each of them deputed to the resolution of a certain adaptive problem. EP pays heed to the mind as a complex biological system of heterogeneous skills, offers possible phylogenetic explanations for cognitive processes, and tries to find these processes' neurophysiological bases (Fig.1).

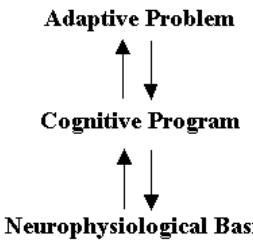

Figure 1. *Three complementary levels of explanation in evolutionary psychology. Inferences (represented by the arrows) can be made from one level to another* (Cosmides & Tooby, 1997)

The mind of *Homo sapiens* can automatically choose and effect the best solution in a given circumstance. Environmental input is processed by a specialized cognitive mechanism and transformed into behavioral output. Cosmides and Tooby use the metaphor of the *Swiss Army knife* to describe cognitive architecture. A Swiss Army knife is made up of many tools to deal with different contingent problems; in a similar way, the human mind is populated by many psychological adaptations to different activities: finding a shelter from the cold, looking for food, recognizing a partner's face, fleeing from danger, and so on. Environmental inputs are necessary to trigger a given cognitive mechanism. Each behavioral or physiological output in each phase of the causal chain of events requires the cooperation of cognitive mechanisms that evolve in response to environmental inputs.

Some species-specific modules—walking, crying, smiling, talking—are harnessed uniquely by humans to effect certain cognitive-behavioral patterns. The mind is an opportunistic device, able to use the best resources available for different purposes. There is no teleology in privileging a certain perceptive modality or in developing a particular cognitive function. In the history of the human species, it was simply a resource that finally came in handy.

Identifying an Emotion

Emotions are complex patterns of physical and mental changes that imply physiological arousal, feelings, and a series of other behavioral and cognitive reactions. Manifesting themselves in response to perceived situations that are significant from a personal point of view, emotions imply a response of the whole organism involving physiological changes in the body, expressive behaviors, and conscious and unconscious subjective experiences.

The main task of emotions is to functionally coordinate the inputs of the senses and the outputs for solving the problem posed by the environment. All emotions have adaptive functions (Fig. 2). They prepare and guide motivated behaviors that promote survival and reproduction.

Interest	→ Orientation/exploration
Fear	→ Avoidance/escape
Anger	→ Impediment to achieve a purpose
Sadness	→ Separation/isolation
Disgust	→ Ejection
Surprise	→ Orientation/acquisition of information
Joy	→ Approach/satisfaction

Figure 2. *Adaptive functions of basic emotions*

Applied to emotions, the concept of adaptation that characterizes evolutionism outlines a new way not only of dealing with the mind-body problem, but also of correlating behavioral manifestations with their physiology. In his study of emotions, Darwin tries to link biological phenomena to psychological processes, identifying a unique function: survival. Furthermore, emotions represent an excellent case of continuity between human and non-human animals. This latter case is described using comparative observations of humans and primates, observations of children, the innovative scientific use of photography to evaluate facial expressions, and the comparison of emotional expressions in different human populations. Darwin (1872) explains the formation of a gradual diversity, even in continuity, between human and animal emotions, inquiring for the first time not only into the proximate physiological causes for how emotions are expressed, but also into the proximate evolutionary causes for the manifestation of certain expressions in certain ways.

In order to understand the emotions, Darwin argues, it is necessary to identify their adaptive advantages. At the basis of emotional expression, he places three general principles: (1) Serviceable Associated Habits, (2) Antithesis, and (3) the principle of actions due to the constitution of the Nervous System, independently from the first of the Will, and independently of a certain extent of Habit.

Let us analyze these principles in detail. The first states that any action able to diminish a tension, to resize an inconvenience, to obtain pleasure or to give relief, turns into a habit thanks to repetition. These actions are transmitted by imitation or learning part of the hereditary heritage of the species. The second principle states that:

> Certain states of the mind lead to certain habitual actions, which are of service, as under our first principle. Now when a directly opposite state of mind is induced, there is a strong and involuntary tendency to the performance of movements of a directly opposite nature, though these are of no use; and such movements are in some cases highly expressive. (Darwin, 1872, p. 27)

According to the third principle, a strong excitation of the nervous system is transmitted to the body's other systems and causes involuntary reactions without adaptive value, including increase in heartbeat, sweating of the hands, change in skin color, and muscular tremor. The original function of emotions is to allow a rapid and precise assessment of one's internal condition in relation to what happens in the surrounding environment. This evaluation allows an appropriate functional and behavioral response.

Starting from Darwin's reflection, evolutionary approaches to emotions have focused on a few psychological phenomena, mainly basic emotions and how these can solve a small group of adaptive problems (orientation/exploration; avoidance/escape; impediment to achieve a purpose; separation/isolation; ejection; orientation/acquisition of information; approach/satisfaction). These studies have been of great scientific worth. By way of example, we need only think of the American psychologist Paul Ekman's (1992, 1999) interesting empirical work on the emotions. Despite such pioneering contributions, the typical evolutionary-psychological account is still reductive (Izard, 1993; Lang, 1995, 2010; Lazarus, 1991; Nesse, 1990; Oatley & Johnson-Laird, 1987; Plutchik, 1980, 1991; Tomkins, 1984). In the next section I will discuss in detail this topic.

An Evolutionary-Psychological Perspective of Emotions

EP's ambitious long-term goal is to create a cartography of human nature. By "human nature", evolutionary psychologists mean the neural and computational architecture typical of our species. As I have shown, the functional components of our mind-brain system are shaped by natural selection to solve the problems of our EEA. From this point of view, EP can be applied to all aspects of our mental life that have consequences on our social relationships: sexual attraction, cooperation, aggression, jealousy, parental or romantic love, aesthetic judgment, mourning, parental care, fear of the enemy, friendship, recognition of the other, and so forth. In such a framework, emotions come to play a crucial role in our mental life.

Emotions are a representative case of adaptation to ancestral selective pressures. Let us take anger and shame as examples. In conflict, animals tend to modify their morphology to simulate their fighting ability. Recent studies point out that, when they are angry, humans monitor the morphological signals sent by others and at the same time modify their own morphology (Sell et al., 2014). It is likely that the muscular movements considered characteristic expressions of anger were selected to increase assessments of the angry individual's strength during competitive bargaining. This hypothesis is antithetical to traditional theories, according to which such expressions are arbitrary (Blair, 2003; Matsumoto et al., 2010) To test this hypothesis – that the specific display of muscle contractions constituting anger face was shaped by natural selection to be functional rather than arbitrary – an investigation by Sell and colleagues (2014) systematically manipulated the seven muscular movements typical of anger one by one

and in the absence of the others. Results showed that subjects who were asked to evaluate the angry faces attributed greater force to those making any of these individual movements. Further, it has been observed that relative to the female, the human male—viewed as the more aggressive sex—exhibits many permanent facial features associable with these movements: a wide nose, broad hands, pronounced cheekbones, lower eyebrows, a lower-positioned brain. This suggests that typical expressions of anger evolved to solve an adaptive problem—that is, bargaining and negotiation during conflicts—with signs of strength and aggression.

Another interesting example is that of shame. According to multiple theories, shame is inherently maladaptive (e.g. Tangney & Dearing, 2003). However, shame is also likely to have been selected by evolution to solve a specific adaptive problem. It would have evolved as a defense against the devaluation of others. As Sznycera and colleagues (2016) explain:

> Shame is a neurocomputational program tailored by selection to orchestrate cognition, motivation, physiology, and behavior in the service of: (i) deterring the individual from making choices where the prospective costs of devaluation exceed the benefits, (ii) negative information others, and (iii) minimizing the adverse effects of devaluation when it occurs. Because the unnecessary activation of a defense is costly, the shame system should estimate the magnitude of the devaluative threat and use those estimates to cost-effectively calibrate its activation: Traits or actions that elicit more negative evaluations from others should elicit more shame. (p. 2625)

Transcultural studies show that in many communities there is a close correlation between shame and devaluation. To feel shame does not seem to be a product of cultural evolution, but rather a universal system that is part of our biology (Sznycera et al., 2018).

As we shown, emotions are key components of Cosmides and Tooby's account (2000; Cosmides & Tooby, 2008). On the one hand, they are vital for survival; on the other hand, they have a crucial role in coordinating individual's mental life. Indeed, the fact that human mind is populated by psychological modules for the resolution of adaptive problems creates a new adaptive problem. To this regard, Cosmides and Tooby (2008) write:

> [The programs] if simultaneously activated, deliver outputs that conflict with one another, interfering with or nullifying each other's functional products. For example, sleep and flight from

> a predator require mutually inconsistent actions, computations, and physiological states. It is difficult to sleep when your heart and mind are racing with fear, and this is no accident: disastrous consequences would ensue if proprioceptive cues were activating sleep programs at the same time that the sight of a stalking lion was activating ones designed for predator evasion. To avoid such consequences, the mind must be equipped with superordinate programs that override some programs when others are activated (e.g., a program that deactivates sleep programs when predator evasion subroutines are activated). Furthermore, many adaptive problems are best solved by the simultaneous activation of many different components of the cognitive architecture, such that each component assumes one of several alternative states (e.g., predator avoidance may require simultaneous shifts in both heart rate and auditory acuity; see below). Again, a superordinate program is needed that coordinates these components, snapping each into the right configuration at the right time. Emotions are such programs. (p. 116)

Adaptive problems are often complex. While avoiding predators, for instance, represents an apparently simple adaptive problem, fleeing from those who threaten us actually requires a number of activities. The subject must (1) identify the enemy, (2) be attentive to stimuli that can distract her/him, (3) suppress other contingent stimuli, (4) understand if the enemy has identified him, (5) understand if there are other enemies, (6) map the surrounding environment to be able to move better, (7) identify a possible escape route, and (8) use all her/his energies to escape. To solve a specific adaptive problem, therefore, the subject must be able to coordinate the operations of many different cognitive adaptations. The coordination of these distinct mechanisms represents a new adaptive problem. For example, the programs responsible for fixing attention on a predator might need to coordinate with the programs responsible for suppressing the motivation for escape behavior. Uncoordinated program activation can lead to grave mistakes such as continuing to look for food instead of escaping a threat. Indecision could be fatal. There are at least two other reasons, in addition to indecision, for which adaptations require coordination. The first is that adaptations can have *opposing outputs*. The second is the so-called *concatenation problem*.

Take the case of disgust. Because of disgust, we are able to avoid situations rich in pathogens—wounds, for example. There are, however, other adaptations, e.g., the quest for a partner, that would lead us to

approach the same situations. Synchronous activation of avoidance and approach leads to non-adaptive behaviors. At first glance, for instance, we can be struck by a person with desirable characteristics. But when we get closer, we see that he has wounds. At this point it is necessary to coordinate the two conflicting motivations to adopt an effective and appropriate solution. Some adaptive problems require subtasks to be performed in a specific order, and this is the *concatenation problem*. The feeling of gratitude for an individual who performs an altruistic action, for example, should increase only after the realization that the act has been done intentionally.

In sum, for EP, emotions are superordinate mechanisms that regulate the activity of other programs for the solution of adaptive problems. They process the signals produced by body and environment during specific problems' solution. Coordination consists in activating the programs appropriate to the situation, disabling conflicting outputs, adjusting program thresholds, managing sequencing and concatenation, and concluding the programs. The details of each activity, of course, depend on contextual variables. As a result, a certain emotion does not necessarily activate the same programs in all contexts. From a computational perspective, the task of orchestration and coordination is complex and of extraordinary importance for the fitness of the individual and the species. The best solution comes from the existence of mechanisms for coordination.

Conclusion

Evolutionary approaches to emotions inspired by Darwin's ideas (e.g. Ekman 1973, 1992) have focused on a small group of emotions that we share with other species, a group selected to respond to the EEA's selective pressures. Extending the range of adaptive problems solved by emotions, evolutionary psychologists identify emotions that lack distinctive signals and are typical of the human species, highlighting the great capacity of emotions to process information.

Emotions like curiosity, guilt, gratitude, envy, jealousy, pride, and embarrassment may have evolved to solve a broad array of adaptive problems tributary to reproductive success. These problems include, but are not limited to, moralistic punishment, hierarchy negotiation, sexual consummation, reputation management, childrearing, and altruism. In this theoretical framework, emotions are superordinate mechanisms, a sort of management-control system (Al-Shawaf et al., 2016; Chenhall, 2003) for

coordinating the activity of such other information-processing programs as attention, perception, memory, categorization, and learning.

References

Adenzato, M., & Meini, C. (Eds.). (2006). *Psicologia evoluzionistica*. Torino: Bollati Boringhieri.

Al-Shawaf, L., Conroy-Beam, D., Asao, K., & Buss, D. M. (2016). Human emotions: An evolutionary psychological perspective. *Emotion Review*, 8, 173–186.

Blair, R. J. R. (2003). Facial expressions, their communicatory functions and neuro-cognitive substrates. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 358(1431), 561–572.

Bowlby, J. (1969). *Attachment and loss. Vol. 1. Attachment*. New York: Basic Books.

Bruni, D. (2017). *Psicologia evoluzionistica. Dal cervello del Pleistocene alla mente moderna*. Rome: Carocci.

Buss, D. (1995). Evolutionary psychology: A new paradigm for psychological science. *Psychological Inquiry*, 6, 1–30.

Buss, D. M. (2012). *Evolutionary psychology: The new science of the mind* (4th ed.). Boston, MA: Allyn & Bacon.

Chenhall, R. H. (2003). Management control systems design within its organizational context: Findings from contingency-based research and directions for the future. *Accounting, Organizations and Society*, 28(2), 127–168.

Chomsky, N. (1959). A review of B. F. Skinner's verbal behavior. *Language*, 35, 26–58.

Cosmides, L., & Tooby, J. (1992). Cognitive adaptations for social exchange. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and generation of culture* (pp. 163–228). New York-Oxford: Oxford University Press.

Cosmides, L., & Tooby, J. (1995). From function to structure: The role of evolutionary biology and computational theories in cognitive neuroscience. In M. Gazzaniga (Ed.), *The cognitive neurosciences* (pp. 1199–1210). Cambridge, MA: MIT Press.

Darwin, C. (1859). *On the origin of species by means of natural selection, or the preservation of favoured race in the struggle for life*. London: Murray.

Darwin, C. (1872). *The expression of the emotions in man and animals*. London: Murray.

Ekman, P. (1973). *Darwin and facial expression: A century of research in review*. New York, NY: Academic Press.

Ekman, P. (1992). An argument for basic emotions. *Cognition and Emotion*, 6(3–4), 169–200.

Fodor, J. (1975). *The language of thought*. Cambridge: Harvard University Press.

Fodor, J. (1983). *The modularity of the mind*. Cambridge: MIT Press.

Izard, C. E. (1993). Four systems for emotion activation: Cognitive and noncognitive processes. *Psychological Review*, 100(1), 68–90.

Lang, P. J. (1995). The emotion probe: Studies of motivation and attention. *American Psychologist*, 50(5), 372–385.

Lang, P. J. (2010). Emotion and motivation: Toward consensus definitions and a common research purpose. *Emotion Review*, 2, 229–233.

Matsumoto, D., Hee Yoo, S., & Chung, J. (2010). The expression of anger across cultures. In M. Potegal, G. Stemmler, & C. Speilberger (Eds.), *International handbook of anger* (pp. 125–137). Springer: New York.

Nesse, R. M. (1990). Evolutionary explanations of emotions. *Human Nature*, 1(3), 261–289.

Oatley, K., & Johnson-Laird, P. N. (1987). Towards a cognitive theory of emotions. *Cognition and Emotion*, 1(1), 29–50.

Pinker, S. (1997). *How the mind works*. New York: W. W. Norton & Company.

Plutchik, R. (1980). *Emotion: A psychoevolutionary synthesis*. New York, NY: Harper & Row.

Plutchik, R. (1991). *The emotions*. Lanham, MD: University Press of America.

Putnam, H. (1967). Psychological predicates. In W. H. Capitan & D. D. Merril (Eds.), *Art, mind, and religion* (pp. 37–48). Pittsburgh: University of Pittsburgh Press.

Sell, A., Cosmides, L., & Tooby, J. (2014). The human anger face evolved to enhance cues of strength. *Evolution and Human Behavior*, 35(5), 425–429.

Skinner, B. F. (1957). *Verbal behavior*. New York: Appleton-Century-Crofts.

Symons, D. (1987). If we're all Darwinians, what's the fuss about? In C. Crawford, M. Smith, & D. Krebs (Eds.), *Sociobiology and psychology: Ideas, issues and applications* (pp. 121–145). Hilsdale, NJ: Erlbaum.

Symons, D. (1992). On the use and misuse of Darwinism in the study of human behavior. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 137–159). New York-Oxford: Oxford University Press.

Sznycera, D., Tooby, J., Cosmides, L., Poratc, R., Shalvie, S., & Halperinc, E. (2016). Shame closely tracks the threat of devaluation by others, even across cultures. *Proceedings of the National Academy of Sciences*, 113(10), 2625–2630.

Sznycera, D., Xygalatasd, D., Agey, E., Alami, S., An, X., Ananyeva, K. I., […] Tooby, J. (2018). Cross-cultural invariances in the architecture of shame. *Proceedings of the National Academy of Sciences*, 115(39), 9702–9707.

Tangney, J. P., & Dearing, R. L. (2003). *Shame and guilt*. New York: Guilford Press.

Tinbergen, N. (1951). *The study of instinct.* Oxford: Clarendon.

Tomkins, S. S. (1984). Affect theory. In K. R. Scherer & P. Ekman (Eds.), *Approaches to emotion* (pp. 163–195). Hillsdale, NJ: Erlbaum.

Tooby, J., & Cosmides, L. (1990). The past explains the present: Emotional adaptions and the structure of ancestral environments. *Ethology and Sociobiology*, 11, 375–424.

Tooby, J., & Cosmides, L. (1992). The psychological foundations of culture. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind:*

Evolutionary psychology and generation of culture (pp. 19–136). New York-Oxford: Oxford University Press.

Tooby, J., & Cosmides, L. (2008). The evolutionary psychology of the emotions and their relationship to internal regulatory variables. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook of emotions* (pp. 114–137). NY: Guilford.

Watson, J. B. (1913). Psychology as the behaviorist views it. *Psychological Rev*iew, *20*, 158–177.

Williams, G. C. (1966). *Adaptation and natural selection*. Princeton: Princeton University Press.