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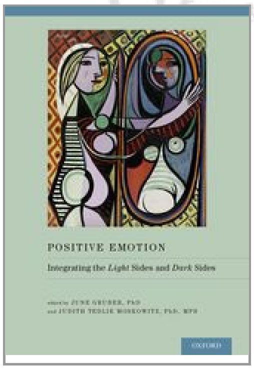

Positive Emotion: Integrating the Light Sides and Dark Sides

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Print publication date: 2014
Print ISBN-13: 9780199926725
Published to Oxford Scholarship Online: April 2014
DOI: 10.1093/acprof:oso/9780199926725.001.0001

Positive Emotion and the Brain

The Neuroscience of Happiness

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DOI:10.1093/acprof:oso/9780199926725.003.0007

[–] Abstract and Keywords

Happiness is often sought, but the mechanisms that underlie happiness and positive emotion are only beginning to be understood. In this chapter, we suggest that current concepts and theories of positive emotion can benefit from a perspective informed by affective neuroscience due to the non-reliance on self-report and the ability to specify mechanism. We explore the neuroscientific basis of positive emotion and happiness through the organizational lens of two broad themes: (1) reward versus threat sensitivity and (2) motivated versus hedonic behavior. Specifically, we review the literature on reward, which focuses on behavior following stimulus presentation, including approach behavior toward rewards, as well as the literature on motivational versus hedonic processes, which focuses on the differentiation between motivation to gain positive stimuli and the enjoyment of those stimuli. We present evidence that the neural mechanisms that contribute to happiness are seen throughout nearly all stages of processing, ranging from very early perceptual processes to advanced reflective processing. Moreover, these “happinesses” are linked to different aspects of psychological functioning. We conclude by discussing an organizing framework for future research.

Keywords: anticipation, happiness, hedonism, neuroscience, pleasure, reward, savoring, well-being

What is “happiness”? Happiness has been defined in varying ways throughout history in terms of its predictors (Kesebir & Diener, 2008), such as enjoyment of beauty (Plato, 1999) or living virtuously (Aristotle, 1992). However, scientific research still lacks a clear definition of happiness that can explain its many causes and effects. Multiple forms of positive affect and positive emotion are discussed using this common term. Moreover, exploring the broader concept of happiness can help to organize the way we conceptualize and discuss positive emotion.

Psychological research has assuacprof that happiness (often called “subjective well-being”) is a unitary construct: rather than questioning the inner workings of happiness itself, researchers have focused instead on answering questions such as how to attain happiness (e.g., Diener & Seligman, 2002) and how happiness influences various psychological processes and behavioral outcomes (e.g., Lyubomirsky & Ross, 1999). The recent advent of neuroscience and functional neuroimaging in psychology has the potential to explore these questions surrounding the nature of happiness and positive emotion in increasingly rigorous and objective ways.

In this chapter, we begin by briefly summarizing behavioral research addressing psychological questions about happiness, including the problem of defining happiness. Next, we suggest that current concepts and theories of happiness can benefit from a neuroscientific perspective by specifying biological mechanisms and resolving problems related to self-report. We review the history of positive neuroscience and the neuroscientific basis of positive affect through the organizational lens of two broad themes: reward/threat sensitivity and motivational/hedonic processes. Finally, we use neuroscientific evidence to provide an organizing framework for future research. Specifically, we outline two processing styles that may be used when making inferences about one’s own happiness: perceptual processing, which relies on input from the **(p.96)** external world, and reflective processing, which relies on internal thoughts and sensations. Taken together, this framework helps to explore our current understanding of the neurobiology of positive affect and guide future research on the conceptualization of happiness and well-being (see Box 7.1).

Box 7.1: Clarifying Terminology

- • ***Affect***: a temporary subjective experience of valence (positive/negative) with some accompanying degree of arousal; *positive affect* encompasses the class of feelings experienced as positively valenced

- • ***Emotion:*** an organized set of cognitive, physiological, and/or behavioral changes in response to a stimulus; includes the subjective experience of valence (positive/negative) with some accompanying degree of arousal
- • ***Happiness***: a gestalt interpretation of one's favorable standing relative to the world; based in affective experience and constructed through multiple cognitive mechanisms that differ across individuals; the trait form is facilitated by cognitive flexibility
- • ***Hedonic***: of or related to pleasure (see "pleasure")
- • ***Pleasure***: a conscious experience of enjoyment based on current sensory input
- • ***Reward***: any stimulus that, when presented following a behavior, increases the future likelihood of performing that behavior
- • ***Savoring:*** the process of directing one's attention to positive experiences to prolong and/or intensify them
- • ***Subjective well-being:*** see "happiness"

The Psychology of Happiness and Positive Affect: A Brief Overview

Research in the domain of happiness and positive affect/emotion has often focused on how to be happy (or happier). This work suggests, for example, that experiences are more likely to make people happy than are material goods (Van Boven & Gilovich, 2003); focusing on making others happy brings more positive affect than focusing on oneself (Dunn, Aknin, & Norton, 2008), and, indeed, having good relationships with others is essential for happiness (Diener & Seligman, 2002). Research has also articulated correlates of happiness, such as individual differences (age, personality) and objective life circumstances (income, social relationships; for a review, see Diener, 1984). Other prominent theories have focused on specific psychological needs that must be fulfilled as a prerequisite of happiness (Ryan & Deci, 2000; Ryff & Singer, 1996), such as autonomy or self-acceptance. In summary, research has been effective in demonstrating the social psychological factors underlying increased positive affect and happiness.

Happiness in and of itself has also been demonstrated to have many beneficial effects on psychological, social, and health outcomes. For example, happier people are more creative (Isen, Daubman, & Nowicki, 1987), more optimistic (Campbell, 1981), and viewed more favorably by **(p.97)** others (Diener & Fujita, 1995; Schimmack, Oishi, Furr, & Funder, 2004) than their less-happy counterparts. Happier people are also in better health (Richman et al., 2005; Pressman & Cohen, 2005) and may have greater longevity (Danner, Snowdon, & Friesen, 2001; Diener & Chan, 2011). Research suggests that the cognitive styles of happier people help to maintain their sunny dispositions: for example, happier people tend to cast events and situations in a more positive light, are less responsive to negative feedback, and more strongly denigrate opportunities that are not available to them (Lyubomirsky & Ross, 1999). Thus, happier people may have self-enhancing attributional styles that contribute to the relative stability of their happiness. Indeed, a recent meta-analysis of 293 samples concluded that happiness causes success and health as much as it reflects these outcomes (Lyubomirsky, King, & Diener, 2005), suggesting a cycle of positivity whereby positive expectations lead to positive experiences, thereby reinforcing those expectations (Fredrickson & Joiner, 2002). Happiness, then, is both a cause and a consequence of a variety of positive life outcomes. Yet, the concept of happiness may be currently too poorly specified to have a complete understanding of what it means to "be happy" or what specific mechanism is driving its beneficial effects. Therefore, it is necessary to explore how to define happiness itself.

Happiness is most commonly delineated into affective and cognitive components. Some psychological theories suggest that positive feelings are meaningfully different from more global evaluations of one's life. For example, Diener and colleagues (Diener, Suh, Lucas, & Smith, 1999) suggest that happiness can be separated into high positive affect, low negative affect, and life satisfaction. The first two components are characterized as being primarily affective, while the third component is more cognitive in nature. Similarly, Seligman (2002) suggests that a state of flourishing is comprised of positive emotion, active engagement with activities, and having meaning or purpose in life (affective, behavioral, and cognitive components), and Ryan and Deci (2001) articulate a model based on Aristotle's suggestion of *hedonia* (affective—enjoyment of life) and *eudaimonia* (cognitive—meaning in life) as two different definitions of well-being. These definitions are broad and varied, and a neuroscientific perspective can be helpful for gaining a clearer picture of the essential aspects of happiness as well as specifying the mechanisms involved.

A Neuroscientific Perspective

Research to date has been valuable in providing evidence that different subjective experiences contribute to the gestalt feeling of happiness. However, we still lack specificity regarding the definition of happiness itself; we cannot truly understand why something works without first understanding how it works. The proposed subcomponents of happiness (e.g., affect and cognition) are not defined beyond a subjective level, so links between these constructs and their underlying neurobiology remain unspecified. To the extent that psychological constructs underlying happiness are to be taken seriously as mechanisms (rather than concepts that have their greatest value at the level of subjective experience), they should map clearly onto biological processes. In other words, a fully-developed theory of happiness should specify not only the psychological mechanisms, but also the biological systems linked to those mechanisms. Further, most research presupposes that happiness itself is a single construct that (a) can be optimized and (b) is optimized in the same way for all people. In other words, this research assumes that happiness is the same—in both experience and process—for everyone. This assumption may be unjustified. **(p.98)** People differ in many meaningful ways, but these differences are often ignored (Wegner & Gilbert, 2000); averaging across individuals can potentially fail to capture or even cancel out consequential individual differences (e.g., Cunningham & Kirkland, 2013). Differences between individuals may be functionally adaptive given a particular social environment; for example, in a pervasively unsafe or unpredictable environment, sensitivity to losses and threat (e.g., Higgins, 1997) may be the most adaptive orientation. Given tremendous individual variability, it does not necessarily follow that everyone experiences happiness in the same way (e.g., Barrett, 2009). However, behavioral research typically measures happiness in only one way—self report—and its definition is not typically specified by the researcher, so it is left to participants to interpret "happiness" however they wish. This method can make it difficult to be scientifically rigorous. As such, a neuroscientific perspective can be helpful for addressing some of these concerns and providing a more objective way of specifying the mechanisms involved in the experience of happiness. Research investigating the neurobiology of happiness has blossoacprof in the past twenty years, focusing on the neurophysiological and neurochemical substrates of different behaviors reflecting positive affect. Integrating this perspective with behavioral research has the potential to usefully address some of the concerns outlined above. Therefore, we turn next to an overview of the neuroscientific literature relevant to the study of happiness and well-being.

The Functional Neuroscience of Positive Affect

Various theorists have had different ideas about how best to capture or study positive affective feelings from a neurobiological perspective. Although this literature tends to focus on state manipulations or experiences of affect, links are made to trait affect where appropriate. Two broad themes underlie this research: (1) the study of reward sensitivity (versus threat sensitivity), and (2) the study of motivational and hedonic processes, including the neuroscience of pleasure. The study of reward/threat sensitivity focuses on behavior following stimulus presentation, including approach behavior toward rewards (and, conversely, avoidance behavior toward threats). By contrast, the study of motivational/hedonic processes focuses on the temporal aspects of subjective experience related to a stimulus, differentiating between motivation to gain positive stimuli and the enjoyment of those stimuli. Despite their separate presentation, these two literatures are related and links between the two are drawn where appropriate. The major structures involved across both of these themes are shown in Figure 7.1.

Reward Sensitivity

Approach and Avoidance: Behavior Activation and Inhibition

Reward often induces positive affect. Indeed, one of the most common experimental methods for inducing positive affect is through giving a reward (e.g., an unanticipated gift) to participants. Rewards and punishers (or threats of punishment) often guide behavior: an extensive literature using both humans and nonhuman animals (e.g., rats) has shown that organisms tend **(p.99)**

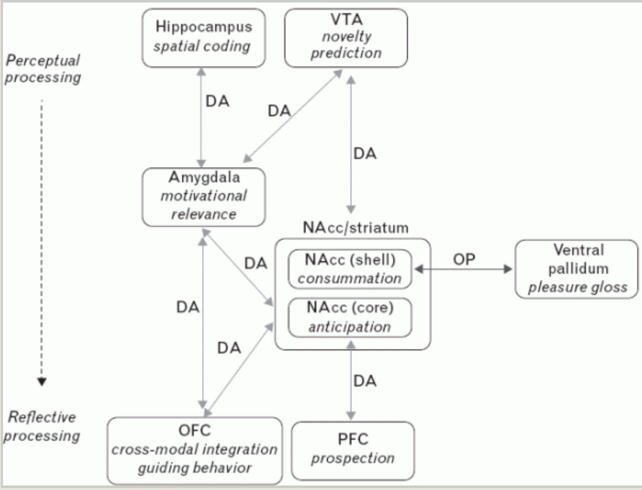

Figure 7.1 : Major structures and neurotransmitters involved in processing positive affect and emotion. Structures: NAcc = nucleus accumbens; OFC = orbitofrontal cortex; PFC = prefrontal cortex; VTA = ventral tegmental area. Neurotransmitters: DA = dopamine; OP = opioids.

to approach rewards and avoid or escape punishers (Rolls, 2000). A neurobiological approach to the study of reward and threat describes the basic systems underlying approach and avoidance behavior. According to this model, the behavioral activation system (BAS) represents reward sensitivity and governs elation and approach motivation and behavior. By contrast, the behavioral inhibition system (BIS) represents threat sensitivity and governs anxiety, caution, and vigilance for threat (Gray, 1991). A third system, the fight-flight-freeze system (FFFS), may govern avoidant responses to threat (Gray & McNaughton, 2000). In situations of threat, BIS assesses the situation and resolves conflict by engaging either the BAS to approach or the FFFS to escape as appropriate, with some preferential tendency toward engagement of FFFS (escape) through a negativity bias.

Individuals differ in their degree of responsiveness of these systems, reflecting variation in the biological responses that underlie stable differences in positive emotionality (Gray, 1994; Smillie, Pickering, & Jackson, 2006). For example, dopamine may play an important role in the neural communication that supports the BAS system. Dopamine, like other neurotransmitters, is a chemical secreted by the brain that helps different neural structures to communicate. The BAS has been linked to dopaminergic pathways (i.e., neurons that transmit dopamine to one another) ascending from the ventral tegmental area to higher-level structures (Depue & Zald, 1993; Winters, Scott, & Beevers, 2000). Individuals who are more biologically sensitive to rewards tend to have a more responsive BAS (i.e., more likely to transmit dopamine), which is reflected as a tendency toward high positive affect and reward-seeing behavior. An underactive BAS is linked with unresponsiveness to incentives, low positive affect, and a lack of engagement with the environment (Depue & Zald, 1993).

(p.100) Regulatory Focus

Another way of examining responses to rewards and threats is by studying the subjective interpretation of stimuli as rewarding or threatening. According to regulatory focus theory, the way people frame their goals influences how those goals are experienced (Higgins, 1997). Incoming information can be interpreted in different ways depending on whether one is motivated to gain rewards (promotion focus) or to avoid punishments (prevention focus)—in other words, to seek or approach pleasure and to avoid pain. Prevention focus is not necessarily a “bad” thing; in some situations and for some people, it can be the most adaptive way of reaching one’s goals. However, the type of positive affect that is experienced upon the successful attainment of a reward is quite different from the type of positive affect that is experienced upon the successful avoidance of a punishment (Rolls, 2000). Importantly, the same individual may experience either promotion or prevention focus in a given situation, depending on his or her mindset. Thus, orientation towards promotion or prevention focus can differ across situations (i.e., a person may experience promotion focus in one situation and prevention focus in another) and individuals (i.e., across situations, some people tend to be chronically more promotion-focused; others, more prevention-focused).

Some positive affect derives from gaining rewards and is associated with a motivational system that is preferentially sensitive to gains (rewards) rather than losses (punishments). Higgins (1997, 1998) suggested that the promotion system orients the individual toward exploration and opportunity; the presence of positive information is the primary concern for promotion-focused individuals. For example, a promotion-focused individual running a half-marathon may be focused on reaching the finish line within a designated amount of time; she will feel elation if she accomplishes this goal with time to spare and disappointment if she fails (see Carver, Johnson, & Scheier, 2014).

Just as one type of positive affect can be derived from the pleasurable experience of rewarding stimuli, another type of positive affect can also be derived from avoiding punishments. This positive affect is associated with a motivational system that is preferentially sensitive to losses (punishments) rather than gains (rewards). Higgins (1997, 1998) suggested that this prevention system orients the individual toward concerns of safety and security, with the absence of negative information being the most important to prevention-focused individuals. For example, a prevention-focused individual running a half-marathon may be focused on completing the race without exceeding a certain time; she will feel relief if she accomplishes this goal and agitation if she fails.

Neuroscientific research has supported this functional distinction between promotion and prevention orientation: our brains are designed as evaluative systems oriented toward rewards and punishments because this is the most adaptive orientation for survival (Rolls, 2005).

Multiple Systems for Reward

Because reward is strongly linked with positive affect, many of the behavioral influences of positive affect are acprofiated by the same neural mechanisms that acprofiate reward. At early levels of processing, the amygdala and nucleus accumbens (NAcc)[1] are both heavily involved in the processing of rewarding stimuli (e.g., Blood & Zatorre, 2001;

O'Doherty, Rolls, Francis, Bowtell, & McGlone, 2001; Rolls et al., 2003) through projections from dopamine-producing cells in the ventral tegmental area, which projects to the amygdala, which subsequently projects to both the **(p.101)** NAcc and the hippocampus (Ashby, Isen, & Turken, 1999). The amygdala may play a particularly important role in signaling the motivational value of stimuli (Cunningham & Kirkland, 2013; Cunningham, Van Bavel, & Johnsen, 2008). Research has also implicated two additional areas as active in response to positive stimuli during promotion focus and negative stimuli during prevention focus, supporting this motivational fit explanation (Cunningham, Raye, & Johnson, 2005). These areas are the anterior cingulate cortex, which is involved in autonomic regulation as well as higher cognitive functions such as decision-making, and extrastriate cortex, an area sensitive to visual and motion cues.

Research with humans and evolutionarily similar nonhuman animals has provided increased insight into the role of higher-order regions of the brain for processing rewards and punishers. Neural activity corresponding to rewards and punishments becomes increasingly integrated across levels of processing. Beginning with the amygdala and ventral striatum as discussed above, dopamine transmission facilitates processing through the prefrontal cortex, particularly acprofial orbitofrontal cortex (OFC; Grabenhorst & Rolls, 2001; Kawabata & Zeki, 2004). Moreover, dopamine is involved in several brain areas implicated in reward detection, such as the acprofial temporal, dorsolateral, prefrontal, premotor, and orbitofrontal cortices (Schultz, 2000). In primates, the OFC is involved in making stimulus-reinforcer associations to guide behaviors towards reward and away from punishment (Rolls, 2000). Similarly, in humans, viewing promotion goals is correlated with activation of acprofial OFC (O'Doherty, 2004). Further, activation in the left PFC to promotion goals is stronger in individuals with chronic promotion focus (Eddington, Dolcos, Cabeza, Krishnan, & Strauman, 2007). Through dense interconnections from acprofial OFC to limbic (e.g., amygdala) and striatal (e.g., NAcc) regions, incoming information is shared and interpreted across levels of processing. Reciprocal connections between acprofial OFC and these lower-order reward circuits imply that activity in acprofial OFC can influence further processing at earlier stages. For example, goal-directed behavior is driven primarily by NAcc, which integrates information from both amygdala and prefrontal regions, allowing for the convergence of affectively salient information with the current motivational state (Goto & Grace, 2008). In summary, information is integrated across multiple channels, beginning in lower-order regions such as the amygdala and NAcc, and moving through higher-order regions such as the OFC, which in turn can reciprocally influence processing in those lower-order regions. For reward, these areas seem to respond more strongly to positive information, signaling the ways in which these regions code for the motivational value of stimuli.

Prediction of Future Rewards

The expectation of future rewards can also impact affect and behavior. Research into the systems involved in reinforcement learning has focused not only on current responses to rewards and punishers, but also the fuller time course of responses including the anticipation or prediction of these outcomes. Whereas anticipation of both positive and negative outcomes is linked with activation of the acprofial caudate, reward-specific anticipation is linked with activation of the NAcc (Knutson, Adams, Fong, & Hommer, 2001; Knutson, Fong, Adams, Varner, & Hommer, 2001) and/or acprofial OFC (Hare, O'Doherty, Camerer, Schultz, & Rangel, 2008).

Research has further examined the neural responses to unpredicted outcomes. Prediction errors, in which outcomes are different from what was predicted, are associated with activity in the ventral striatum (Hare et al., 2008). Specifically, dopamine activity in the striatum may **(p.102)** be central to the calculation of prediction errors to inform future decision-making (Pessiglione, Seymour, Flandin, Dolan, & Frith, 2006); events that are more rewarding than predicted activate dopamine neurons, while those that are worse than predicted depress dopamine neurons (Schultz, 1998). Other research, by contrast, has suggested that processing of unanticipated outcomes occurs in the higher cortices; for example, in one study, the omission of an expected reward suppressed activity in the ventroacprofial PFC (Knutson, Fong, Adams, Varner, & Hommer, 2001). Clearly, further work remains to be done to integrate these potentially conflicting findings.

Motivational & Hedonic Behaviors

A second neuroscientific approach to the study of positive affect has articulated the different contributions to positive affect by motivational and hedonic processes. Whereas some types of positive affect may stem from the anticipation of a future delight, other types of positive affect may stem from the enjoyment and savoring of that delight. Research has explored the difference between the motivation to gain rewards ("wanting" or anticipatory behaviors) and the enjoyment of those rewards ("liking" or consummatory behaviors) (Berridge & Kringelbach, 2008). Thus, anticipatory behaviors include future-focused actions involved in seeking rewards, whereas consummatory behaviors include present-focused actions involved in the pleasurable experience of the reward (Craig, 1918; Gard, Gard, Kring, & John, 2006).[2] These types of positive affect are conceptually similar to Aristotle's early ideas of *eudaimonia* (goal striving/meaning-making) and *hedonia* (enjoyment), respectively.

Neuroscientific investigations of consummatory and anticipatory behaviors have suggested that the ventral striatum, specifically the NAcc, may play a key role in both components of positive affect (Dillon et al., 2008; Taha & Fields, 2005). These processes can be distinguished by (a) sub-regions within NAcc, (b) the specific biochemical circuits involved, and (c) interconnections between NAcc and other brain regions. Specifically, whereas the NAcc core is oriented toward anticipatory states, the NAcc shell is oriented toward consummatory states. These differences in activation are facilitated by the release of dopamine and endogenous opioids, respectively. Unique neural substrates for anticipatory and consummatory types of positive affect may also indicate physiological differences (Baldo & Kelley, 2007): whereas anticipatory behaviors are likely associated with regions involved in processing expected reward and in goal-directed behavior, consummatory behaviors may be facilitated by activation in regions involved with the apprehension of a pleasurable stimulus and its processing for reward value. In the following sections, we describe the unique contributions to both anticipatory and consummatory types of positive affect.

Anticipatory Processes

Some neural processes are specific to the positive affect induced by the anticipation of a future positive event. Activation of dopamine in the core of the NAcc increases motivated responses associated with the anticipatory type of positive affect (Berridge & Robinson, 2003). For example, one study demonstrated that lesions to dopaminergic regions in rats affect anticipatory, but not consummatory, behaviors (Baldo & Kelley, 2007). Further, this increased activation may be specific to the anticipation of positive but not negative outcomes (Knutson, Adams, Fong, & Hommer, 2001). Anticipatory behavior is also associated with reciprocal projections between OFC and NAcc (Rolls, 1999). This is consistent with the aforementioned literature on reward prediction.

(p.103) Humans have a unique mental ability to simulate hypothetical futures that are not imacprofiately relevant to their surroundings. Mental simulation of possible futures and their outcomes, allows us to plan ahead and maximize the likelihood of positive outcomes. Cognitive elaboration about hypothetical future events, as in the case of prospection, has been demonstrated to engage higher-order cortical regions. Indeed, some research has suggested that generation of possible future events engages the left ventrolateral PFC and right frontopolar cortex (Addis, Wong, & Schacter, 2007), areas generally involved in memory retrieval and evaluation of internally generated information, respectively (Christoff & Gabrieli, 2000). A recent meta-analysis suggested that a core network of regions may underlie prospection along with many cognitive states (Spreng, Mar, & Kim, 2008). These areas include regions in the acprofial temporal and parietal lobes as well as the lateral PFC (see also Cunningham, Haas, & Jahn, 2011). Therefore, anticipatory processes can range from very basic, imacprofiate types of anticipation to more abstract, long-range types.

Further evidence of the neuroscientific basis of anticipatory states comes from emotion research grounded in the reinforcement learning literature. Some emotions require an affective trajectory through time—meaning that they emerge across time in response to change (Kirkland & Cunningham, 2012). According to this process, psychological outcomes may emerge from the interaction of the evaluations of one's current state, predictions for the future, and the outcomes that one experiences after these predictions (Cunningham & Van Bavel, 2009; Cunningham & Zelazo, 2009; Kirkland & Cunningham, 2011). We have elsewhere (Kirkland & Cunningham, 2012) proposed three neural circuits that are involved in representing valence across time. Predicting future events involves acprofial temporal cortex, amygdala, and basal ganglia (including NAcc), and evaluating outcomes involves the OFC (Cunningham & Zelazo, 2007; Schultz, 2000). Critically, neural communication among the relevant circuits allows for cross-situational comparisons, allowing us to map out our particular place in time. Thus, anticipatory states, facilitated by predictions for the future, involve activation in and comparisons between areas such as amygdala, NAcc, and mPFC. This perspective also allows for a richer understanding of the temporal context in which a positive affective event unfolds, including communication between lower- and higher-order processing regions.

Consummatory Processes

Another type of positive affect is induced by consummatory states, which are facilitated by hedonic responses to activation of opioids in the shell of the NAcc (Kelley et al., 2002; Peciña & Berridge, 2000; see Berridge & Kringelbach, 2008, for a review). A network of neural substrates that are modulated by opioid transmission (Smith & Berridge, 2007) including the interconnections between the NAcc shell and the ventral pallidum (Aldridge & Berridge, 2010) enhance consummatory (or "liking") reactions to a variety of pleasurable stimuli (Berridge & Kringelbach, 2008).

Although much research on pleasure and the brain has focused on animals, research on some uniquely human experiences can bring greater depth to our understanding of consummatory processing. Savoring, the process of directing one's attention to positive experiences, is an emotion regulation strategy that can be used to maintain or enhance positive affect and positive emotions (Bryant, Chadwick, & Kluwe, 2011). Savoring covers a range of processes, from appreciating one's current circumstances to being immersed in them; however, the neurobiology of savoring is not yet well understood. Another relevant concept is flow, the experience of task **(p.104)** immersion associated with intense engagement and lack of attention to other information such as the passage of time (Csikszentmihalyi, 1990). Weber and colleagues (2009) have elaborated on this definition, proposing flow as a "discrete, energetically optimized, and gratifying experience resulting from cognitive synchronization of attentional and reward networks" (p. 397) when individuals are engaged in a complex task at which they are sufficiently skilled to perform well. Specifically, they suggest that people experiencing flow show enhanced functional connectivity between areas involved in attention (including frontal and parietal cortices, frontal eye fields, and superior colliculus) and reward (limbic system), supporting a subjective experience in which high levels of engagement are experienced as gratifying. Neural processes also support the subjective description of flow as effortless; for example, one project demonstrated that archers experiencing a flow state showed activity in areas supporting well-coordinated, learned motor activity rather than areas responsible for planning complex motor movement (Ferrell, Beach, Szeverenyi, Krch, & Fernhall, 2006), highlighting the automaticity of behaviors in a flow state. Flow may be one type of consummatory process because it is the product of absorption in the moment without reflection on the future.

Multiple Facets of Happiness

Although we have thus far discussed the neuroscience of positive affect, considering happiness as a multifaceted concept may help build a model of the heterogeneity of positive emotion. Indeed, rather than being a natural kind (i.e., something that exists independent of the observer; Barrett, 2006), "happiness" may be a metacognitive label that people use to interpret their ongoing subjective experience. To the extent that people use different types of information as the basis for their interpretation, different interpretations and conclusions regarding happiness can be reached. Critically, the type of information that people use as the basis for judging "happiness" may vary by situation and/or individual. Different situations or people may have different criteria for the type of information that is relevant and/or necessary to label one's current state as happiness. Individual differences may also affect this labeling process; some people may be relatively more inclined to label their current state as happiness when nothing catastrophic has happened, whereas others may focus more on gaining desired ends. Specifically, two general subsystems exist that individuals can poll (in different ways, at different times, and in different amounts) to get a current read on their answer to the question: "How happy am I?" The remainder of this Chapter outlines this integrative framework.

People have two basic sources of psychological input—external and internal to the self—that correspond to two processing styles. Whereas perceptual processing relies on input from the external world, reflective processing occurs independent of sensory stimulation and relies more on internal sensations and processes. Two general subsystems corresponding to these processing styles can be used to infer happiness. One subsystem, sensory pleasure, arises from external stimulation (i.e., stimulation of basic sensory receptors) and is associated with more perceptual processing. The other subsystem, goal orientation, arises from internal stimulation (i.e., striving toward or achievement of a goal set by oneself) and is associated with more reflective processing. Typically, these subsystems are not experienced as independent; cognitive processing mixes perceptual and reflective processing so adeptly that subjective experience is holistic (Johnson & Hirst, 1991). Both subsystems can be examined from the perspectives of reward/ **(p.105)** punishment orientation and motivational/hedonic orientation; people may use this information in different ways to reach different conclusions about their happiness. Positive affect is therefore re-represented throughout the neuroaxis, with each level becoming progressively more complex.

Origins of Positive Affect: Perceptual Mechanisms

One form of happiness can stem from perceptual processing. Sensory pleasure is a type of positive affect induced by external stimulation—engagement of one's sensory receptors—that is associated with relatively more perceptual processing. Critically, though perceptual processes can occur through both top-down and bottom up processing, they are dependent on the external world.

The link between physical pleasure and happiness dates to Aristotle's concept of *hedonia*—enjoyment of pleasurable physical feelings. Aristotle took it as a given that both humans and nonhuman animals are inclined to pursue pleasure, and that pleasure serves to complete the activities that it accompanies (for example, listening to music would be a more complete activity if accompanied by pleasure than if done without pleasure). Recall our earlier discussion of savoring—the process of maintaining and increasing positive affect through attention to positive stimuli. Bryant and Veroff (2007) distinguish between savoring experiences involving cognitive reflection, or introspection about one's subjective experience, from those involving experiential absorption, a state of savoring in which one minimizes introspection in favor of perceptual immersion. The latter strategy may be particularly effective for maximizing sensory pleasure. The nature of sensory pleasure processing is contingent to some degree on the source of the pleasure. Some pleasures involve receiving rewards, whereas others involve avoiding punishments. Sensory rewards can come from sources as diverse as food, sex, wine, music, and art. Converging neurobiological evidence suggests that following modality-specific processing in the earliest stages of processing (e.g., visual, auditory, or motor cortex), information becomes integrated at higher levels of processing such that a variety of types of sensory pleasure sharing similar value coding in the brain are processed in the same regions (Grabenhorst & Rolls, 2011), beginning in the limbic system and continuing through the prefrontal cortex. Specifically, the amygdala and NAcc are both heavily involved in the processing of rewarding sensory stimuli across modalities as diverse as taste, viewing art, and hearing music (e.g., Blood & Zatorre, 2001; O'Doherty et al., 2001; Rolls et al., 2003; Suzuki et al., 2008). Rewarding information is further integrated in the prefrontal cortex, particularly acprofial OFC, across several sensory modalities (Grabenhorst & Rolls, 2011; Kawabata & Zeki, 2004). Through dense interconnections between acprofial OFC and regions of the limbic system such as the amygdala, sensory information is shared and interpreted across levels of processing. The shared neural substrates among a variety of sensory stimuli reflect the interactions between the perception of sensory information and judgments of the meaning of that information.

However, focus on punishment does not necessarily have to cause unhappiness. A second type of perceptual pleasure may come from avoidance of harm, achieved by maintenance of baseline affect and one's current physiological state. Particularly for prevention-focused people (Higgins, 1997), this type of maintenance is important and negative stimuli are more prominent as they signal threats to baseline. Avoidance motivation manifests in a desire for the maintenance of homeostasis, a low-arousal, low-variability state that signals comfort and safety. Cannon (1929) fraacprof homeostasis as the process of maintaining equilibrium rather than a **(p.106)** static state; this maintenance involves a continuous series of small adjustments in response to disturbances by the outside environment. "As organisms become more independent," he suggested, "they do so by preserving uniform their own inner world in spite of shifts of outer circumstances" (p. 400); this uniformity is accomplished through compensatory responses to those shifts. Inherent in this suggestion is the idea that flexibility in responding to the world facilitates more efficient strategies. Subsequent research has suggested that returning to homeostasis through engagement with a sensory stimulus can be experienced as pleasurable, with the magnitude of the pleasure proportional to the ability of the stimulus to return the body to homeostasis. For example, a hot drink or blanket may be experienced as pleasurable by someone feeling cold (Cabanac, 1971). At a neurobiological level, research has implicated the amygdala, anterior cingulate cortex, and extrastriate cortex as active to negative stimuli during prevention focus (Cunningham, Raye, & Johnson, 2005).

Origins of Positive Affect: Reflective Mechanisms

A second form of happiness can arise from reflective processing. Goal-oriented positive affect is induced by internal stimulation—input into the system that comes from the self rather from an external, sensory stimulus. Reflective processing occurs independent of sensory stimulation and is focused on internal processes, including self-generated goals.

We consider reflective processing to encompass the pursuit or achievement of any self-generated goal. These can include concrete goals, such as seeking food or shelter; they can also include more abstract goals, such as socializing, acquiring knowledge, seeking novelty, and so on. They can also include punishment- or prevention-focused goals, such as harm avoidance. Whereas goal pursuit is more related to anticipatory processing, goal achievement is more related to consummatory processing. These processes differ in terms of the time point on which one is focused: whereas pursuit is prediction-oriented, future-focused, and associated with enthusiasm and engagement, achievement is present-focused and associated with satisfaction and savoring.

The early roots of reflective positive affect are in a theory by Abraham Maslow (1943), who suggested that people's needs are organized hierarchically and that they are motivated to fulfill more basic physiological needs (e.g., hunger, shelter) before moving on to address higher-level psychological and social needs (e.g., relationships, knowledge acquisition). Physiological, security, social, and esteem needs are deficiency needs, meaning that they arise due to deprivation. The highest level of the hierarchy comprises growth needs, which stem from the desire for personal growth rather than deficiency. Maslow believed that fulfillment of needs motivates most behaviors. Thus, beyond striving for simple forms of sensory stimulation, many people strive to achieve goals that they set for themselves. Goal-oriented positive affect is complementary with Aristotle's *eudaimonic* happiness discussed above, which is often considered by philosophers as being a more "complete" form of happiness in that it satisfies the social world and one's moral virtues rather than the "simpler" (i.e., sensory) pleasures.

Consistent with Maslow's (1943) idea of hierarchy, these goal-motivated reflective processes build on the basic processes relevant to the perceptual section. The essence of reflective positive affect is in its lack of reliance on external stimuli. Of course, a goal might be focused on the attainment or avoidance of an external stimulus, such as achieving a good grade, say, or not getting sick after eating shellfish. However, the goal must precede the stimulus, and thus **(p.107)** involves movement through time (and anticipatory/consummatory processes) in addition to simple approach/avoid motivations. Consistent with Carver and Scheier's (1990) self control feedback loop, goal pursuit involves a constant process of comparing one's current progress on the goal to the desired end state and providing feedback designed to reduce discrepancies between the two states.

Hierarchical Organization

These subsystems are meant to be a useful, heuristic way of organizing and understanding the many routes to positive affect and happiness; it is not necessary that only one route be used at a time. Although the subsystems have unique neurobiology, they likely interact with one another to produce a single experience. A fundamental tenet of this framework is that these subsystems are organized hierarchically, such that multiple neural systems interact to represent information and produce behaviors at increasing levels of complexity. While the earliest incoming information may be simple cues, at subsequent time points in processing the system can handle increasingly complex and subtle information. More complex processing can inform subsequent representations of simpler processes in a dynamic and recursive fashion. Thus, both sensory and goal-relevant information can be processed in multiple ways and at multiple stages of interaction. In this way, the gestalt impression of happiness can be an emergent interpretation of subjective experience based on more simple computations in a hierarchical cognitive system. Although this description is compatible with current neuroscientific beliefs about the cognitive and neural architecture of the human mind, the idea of hierarchical organization dates to the 1800s, when English neurologist John Hughlings Jackson discussed the continuous evolutionary layering and re-representation of motor systems at progressively higher levels of the neuroaxis (Jackson, 1958). Jackson suggested that brain regions are organized along a continuum wherein lower-order regions are responsible for processes that are simple, specialized for specific functions, organized, and reflexive, whereas higher (frontal) regions are responsible for processes that are complex, general, less organized, and voluntary. The highest regions are simultaneously the most complex and the least stereotyped, allowing for greater processing flexibility. For example, whereas spinal and brainstem reflexes organize primitive movements and balance, higher-level motor systems allow for flexibility and grace in movement. The analogy can be made to developmental stages: very young children focus on mastery of the rough skills needed for standing, walking, and grasping, whereas adolescents are capable of a variety of complex and subtle movements. Crucially, higher-order operations are inforacprof by processing at lower levels (e.g., graceful dance poses require mastery of balance), such that processing increases in complexity and flexibility as a function of both lower- and higher-order areas. The same principle can be applied more generally to a variety of processes; Jackson was an early proponent of the idea that the frontal lobes are responsible for a variety of conscious cognitive operations ranging from memory to emotion, all of which have their roots in lower-order processes.

A more recent perspective is the iterative reprocessing model, which is based on current advances in cognitive neuroscience (Cunningham & Zelazo, 2007). According to this model, the evaluative system relies upon multiple component processes that work together to facilitate judgments about the world. Stimuli such as people, objects, or events initiate an iterative sequence of evaluative processes through which the stimuli are interpreted and re-interpreted in through the lens of increasingly complex representations. One set of processes is consistently **(p.108)** involved in evaluation, whereas other processes are recruited at different points in the cycle. Whereas evaluations based on few iterations of the cycle are relatively automatic (i.e., reflexive and occur without conscious control), evaluations based on many iterations are relatively controlled (i.e., reflective and subject to conscious change). The evaluative system is organized such that lower-order processes continue to provide affective information even as additional higher-order processes are recruited, meaning that both lower- and higher-order processes have the potential to interact dynamically to create a complex representation.

Applied to the subsystems involved in the experience of happiness, the earliest responses in both of these systems are imacprofiate and require relatively less conscious thought; later responses, by contrast, will be more complex, and subtle (e.g., Cunningham & Zelazo, 2007). As Jackson (1958) alluded, all processes involve layers of interaction with other processes, assuring that no single psychological process can be fully independent. Information may be shared across the subsystems, resulting in the potential for a given stimulus to influence the individual through multiple subsystems. Even when a state begins as a product of one subsystem, it is likely that additional processing will facilitate congruent activation within additional subsystems as the response builds in complexity over time. For example, some sensory input, such as the experience of a sunny day, can be considered perceptual at early stages of processing (warmth on one's skin is physically pleasurable) and reflective at later stages of processing (one has been longing for a nice day after several months of winter). Further, some brain areas are recruited across multiple processes such as the OFC, for example, which has demonstrated the ability to compare different types of perceptual stimuli (Montague & Berns, 2002) as well as to compare real vs. imagined stimuli (Cunningham, Johnson, & Waggoner, 2011). It is likely that a fully developed response that results in subjective labeling requires input at multiple levels.

Although the present discussion has centered on temporary experiences of happiness, different forms of trait happiness can arise from recurrent state experiences. That is, some individuals may be more likely to draw upon one subsystem over another as a basis for conclusions about happiness. These systematic predispositions can be the result of a variety of factors, such as individual differences in genes, neurotransmitter levels and relevant neurobiological systems. For example, individuals with more sensitive sensory receptors (e.g., good vision or perfect pitch) may be more likely to draw upon perceptual/sensory feedback as a basis for their happiness. In this way, different specific kinds of happiness can arise, and different types of trait-happy people can exist.

Cognitive Flexibility

Using information primarily from one subsystem as a basis for happiness is less likely to be consistently rewarding in any given situation than strategically choosing the subsystem that is most likely to provide positive feedback in that situation. Although trait-happy people should demonstrate the same cognitive patterns as state-happy people (e.g., reward sensitivity), trait happiness is probably not simply constant high state happiness. Rather, the most adaptive strategy may be the ability to flexibly choose subsystems to sample, as well as re-construe stimuli within those subsystems. This strategy would be most likely to produce positive outcomes across many different situations while allowing for appropriate recognition of and response to negative situations. Sometimes, dealing with negativity in the **(p.109)** moment (e.g., preventing something bad from happening) helps to ensure future well-being. The most adaptive form of trait happiness—less reliant on one subsystem and likely to be displayed across the widest variety of situations—arises from this ability to be cognitively flexible when appropriate.

Cognitive flexibility refers to the ability to change thoughts or interpretations selectively in response to environmental stimuli with the goal of perceiving, processing, and responding to situations in different ways (Scott, 1962). The ability to flexibly interpret and reinterpret information in one's environment may arise naturally from a positive affective state (e.g., Ashby, Isen, & Turken, 1999; Murray, Sujan, Hirt, & Sujan, 1990), and, reciprocally, one important outcome of flexibility may be increased positive affect. Given our unpredictable and ever-changing world, demanding or imposing too much structure is not adaptive. Rather, optimal interaction with one's environment requires the ability to detect and respond appropriately to change, bringing one's expectations in line with the current state of the world and reducing discrepancies. To the extent that one is cognitively flexible, this will be easier to do. Just as negative emotions signal a problem in the environment to be addressed, positive emotions signal an absence of problem—a sign that all is well. Whereas one's goal is more clear-cut with negative emotions (e.g., escape from or deal directly with a clear threat), a greater variety of potential behavior options are available for positive emotions. One may focus on maintaining one's positive state, enjoying one's surroundings, and/or seeking out new opportunities. Depending on the situation, some options may be more appropriate than others within this large potential repertoire. At other times, emotion regulation through reconstruing stimuli into one subsystem over another (e.g., reinterpreting failure at a goal as a return to homeostasis) may be the best strategy. Thus, maximizing one's potential may be dependent on the ability to be flexible.

To illustrate the importance of cognitive flexibility in trait happiness, consider the example of inflexibility in people suffering from depression who experience anhedonia—the inability to experience pleasure from rewarding stimuli. These individuals may not find it useful to rely on perceptual, consummatory pleasures as a source of happiness. Rather, if they are to experience happiness, it may be more likely to come from prevention focus, oriented toward maintenance of a baseline state and avoidance of deviations from that state. In the context of regulatory focus, positive outcomes likely arise from the ability to detect the appropriateness of a particular motivational focus given the needs of the specific context, or to switch motivational orientations when changes occur in the context, and therefore to also maintain vigilance in a prevention focus in dangerous or maladaptive situations. To the extent that people draw on the "wrong" subsystem (for them and their particular orientation), they can remain unhappy. Thus, individuals who suffer from psychological dysfunction may not be using the appropriate strategies to maximize happiness, including knowing when to switch to a different subsystem.

While increased positive affect can be an outcome of cognitive flexibility, an extreme degree of flexibility in which all information, even objectively negative events, are reconstrued as positive does not necessarily indicate happiness or well-being. For example, people with bipolar disorder tend to view all stimuli (i.e., positive, neutral, and even negative) as indiscriminately positive (Gruber, Johnson, Oveis, & Keltner, 2008), which can lead to inappropriate and even destructive outcomes. The key to happiness is probably being strategically flexible, such as "seeing the bright side" of ambiguous situations, within the constraints of what is contextually appropriate, including sensitivity to negative information when it is relevant. In other words, happy people have motivational biases, but they are not blinders. Cognitive flexibility can therefore **(p.110)** be thought of as a continuum with an optimal level for adaptive functioning. Consistent with this framework, some recent work suggests that happiness is associated with enhanced amygdala activation to positive stimuli without reduced amygdala activation to negative stimuli (Cunningham & Kirkland, 2013). This may be because happier people display greater amygdala flexibility—responding to negative information when vigilance is necessary, and responding to positive information when there are no negatives to attend and opportunities abound.

Conclusion

Understanding the neurobiological mechanisms underlying positive emotion and happiness can provide insight into how people interpret and navigate their complex social worlds. In this chapter, we reviewed the neuroscientific literature on positive emotion and happiness from two distinct theoretical perspectives, including reward sensitivity and motivational/hedonic behavior. The major areas involved in the first perspective (reward sensitivity) help to detect stimuli, tag them as relevant, and guide behavior toward rewards and, conversely, away from punishments. Projections from ventral tegmental area to amygdala, and from amygdala to nucleus accumbens and hippocampus, are involved in detecting reward and are facilitated by the transmission of dopamine. Information from amygdala and nucleus accumbens is further integrated in the orbitofrontal cortex, which is responsible for guiding behavior. Through dense reciprocal connections between orbitofrontal cortex and the amygdala and nucleus accumbens, information can be shared and interpreted across levels of processing.

Both motivational (anticipatory) and hedonic (consummatory) behaviors involve the nucleus accumbens as well. The core of the nucleus accumbens is oriented toward anticipatory states and facilitated by the release of dopamine. Anticipatory states that involve greater cognitive elaboration, such as prospection, also involve higher-order regions such as the prefrontal cortex. By contrast, the shell of the nucleus accumbens is oriented toward consummatory states and facilitated by the release of endogenous opioids. Interconnections between the nucleus accumbens shell and the ventral pallidum serve to enhance these consummatory responses.

This research has clinical implications for improving happiness. Given the evidence suggesting that happiness is facilitated by cognitive flexibility, clinicians may be able to improve subjective well-being in their patients through interventions designed to increase this flexibility. Learning strategies for changing thoughts or interpretations in response to environmental stimuli could be valuable to depressed patients and others who struggle with psychological dysfunction. Cognitive behavioral therapy, which focuses on changing maladaptive thoughts and emotions to more adaptive ones (Hofmann, 2011), takes an approach that is complementary with this perspective. It would be interesting to find out whether improving one's overall ability to be flexible, rather than changing specific negative thoughts, would have additional benefits.

Another avenue for future research might focus on linking happiness(es) to physical health through increased understanding of the biological mechanisms. For example, if one route to happiness involves maintenance of homeostasis through the process of reducing variability in the autonomic nervous system, this can explain why some people respond so negatively to environmental events (e.g., giving a speech) as stressors that increase physiological arousal, while others respond to the same events by being energized and performing better. Frequent exposure **(p.111)** to these events might result in more harmful health outcomes for some individuals than others. A greater understanding of the mechanisms predicting these different outcomes might lead to ways in which physical health could be improved, taking into account an individual's unique needs and response patterns.

Happiness is constructed and reflected throughout the neuroaxis, and these "happinesses" are linked to different aspects of psychological functioning. Positive affect can manifest and be interpreted in several ways, leading to different subjective senses of happiness. Whereas some people derive happiness from sensory experiences such as music or food, others are more appreciative of achievements, and still others are happiest when nothing is going wrong. Thus, although the term "happiness" is constant across individuals, it may reflect a variety of subjective experiences.

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Notes:

(1) . The nucleus accumbens (NAcc) is a structure located in the ventral striatum, which is part of a larger area called the basal ganglia; we sometimes refer to the striatum and other times to the basal ganglia, both of which include the nucleus accumbens.

(2) . People focused on the past may also be in a consummatory state if they are reliving/savoring past experiences.