Emotion, Motivation, Personality and Their Neurobiological Foundations

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In this chapter we will deal with three basic components of the human psyche: emotions or feelings, motivation and personality. In the spirit of bridging the gap between the psychosciences and the neurosciences, the first aim is to show what emotions and motivational states are from a psychological point of view, how they result in characteristics of a person's personality, and how these determine our state of mind and our behavior. Secondly, we want to ask to what extent these psychological phenomena can be linked to structures and functions of the brain. Particularly exciting is the question on which structural and functional level correlates can be found. We will see that the level of neuronal networks and processes at the synapses play a special role here, which in turn are influenced by genetic and epigenetic factors as well as prenatal and postnatal environmental influences and experiences.

Learning Objectives

After reading this chapter, the reader should be familiar with common psychological statements about emotions, motivation, and the development and structure of personality, as well as the neurobiological basis of these components of the human psyche.

6.1 Emotions

In psychology, the study of emotions or feelings experienced a first peak towards the end of the nineteenth century and in the early twentieth century with authors such as William James, Wilhelm Wundt and William McDougall. However, this development was hampered for decades by the dominance of **behaviorism**, for which "internal states" such as feelings, thoughts, or intentions had no explanatory value whatsoever. It was only in the 1980s that psychologists began to focus more and more on the question of what emotions are, how they arise and what influence they have on our thinking and behaviour. This then triggered the interest of neurobiologists, who were often also trained psychologists or psychiatrists. Milestones here were the works of Antonio Damasio, Jaak Pansepp and Joseph LeDoux—to name but a few.

Behaviorism

Behaviorism is a very influential psychological theory that developed since the beginning of the twentieth century, mainly in the USA, through researchers such as E. L. Thorndike, J. B. Watson and especially B. F. Skinner. F. Skinner and, in contrast to the continental European "psychology of understanding", advocated the view that psychology must be strictly limited to observable stimulus-response relationships when studying human and animal behaviour. Assumptions about "internal" mental-psychic states were useless. Moreover, it was held that animal and human behavior is more or less exclusively learned. For psychology and behavioral science, Skinner developed seminal "laws" of learning in the form of operant conditioning in addition to those of classical conditioning described by Pavlov. This also became the basis of widespread behavioral therapy.

6.1.1 What Are Emotions and Feelings?

In everyday psychology, the term "emotion" is equated with "Gefühle" in German. In the following, however, we want to define the term "emotion" more broadly in the sense of a state that "moves" us either unconsciously or consciously—according to its origin from the Latin word *movere*. "*Feelings*", on the other hand, we take to be a conscious state of experience and thus a *sub-form* of emotions that differs from cognitive states such as thinking, imagining and remembering. However, feeling states are

usually associated with concrete perceptual and cognitive content: As we recognize, remember, or imagine certain things, we have certain feelings. However, some feelings, especially in the form of moods such as dejection, can also occur without content (one then does not even know why one feels so depressed), which is not true for perceptual and cognitive states.

Feelings can have different *intensities* and be *positive* or *negative*—the latter is called their **valence**. In addition, feelings, especially those of higher intensity, often also called **affects**, usually occur together with *physical forms of expression* such as facial *expressions*, gestures, posture, voice pitch as well as with *vegetative reactions* such as feelings of anxiety, sweating, trembling, rapid breathing and a higher pulse rate. Antonio Damasio (1994) refers to these as "somatic markers" that occur automatically along with perceptions and events. Finally, many feelings have a *motivational* effect, i.e. they drive us to do or seek out certain positive things (approach behaviour, *appetence*) or to avoid negative things (avoidance behaviour, *aversion*; ▶ Sect. 6.2).

In the psychology of emotions, **valence** refers to the positive or negative valence of a (conscious) feeling, depending on whether it is accompanied by joy, pleasure or even elation, or fear, anxiety, sadness and disgust. This then results in certain motives or action tendencies such as approach and avoidance.

While feelings are by the above definition conscious, there are also unconscious emotions. They may remain unconscious if the stimuli that trigger them are too brief or "masked" (▶ Sect. 6.1.3) or too weak to cross the threshold of consciousness; they may also be "repressed" from a psychoanalytic perspective. They may trigger vegetative reactions such as an increase in blood pressure or respiratory rate, behaviours such as avoidance behaviour, or musculo-skeletal tension, without us necessarily noticing.

6.1.2 How Many Emotions Are There and How Do They Arise?

There ist a long-standing debate of whether there is a basic emotional make-up with a certain number of independently existing affects or emotions that can also be found as separate "modules" in the brain, whether emotions or feelings have a continuum or whether all affects/emotions can be reduced to only *two basic polarities*—mostly "positive/desirable" vs. "negative/to be avoided" and low vs. strong arousal.

The psychologist Paul Ekman advocates a *modular* model of emotions, whereby he understands emotions to be short-term emotional states related to a specific stimulus (Ekman 1999, 2007). He assumes a total of 15 "*basic emotions*", namely *happiness/amusement*, *anger*, *contempt*, *contentment*, disgust, *embarrassment*, *excitement*, *fear*, *guilt*, *pride* in *achievement*, *relief*, *sadness/distress*, *satisfaction*, *sensory pleasure*, and *shame*. Other affective states such as *grief*, *jealousy*, *romantic* and *parental love* are for Ekman rather longer-term affective states or moods and therefore not necessarily to be considered as emotions. These 15 emotions are characterized for Ekman by a unique combination of external and internal physical features, e.g., a typical facial expression, a typical sound utterance (sounds of pain, sadness, joy, etc.), and a characteristic state of the autonomic-vegetative nervous system.

The Estonian-American neurobiologist Jaak Panksepp, who died in 2017, assumes that there are clearly definable *basic affective-emotional states that* are characterized by different neuronal "modules" in the brain.

In his opinion, these can be detected via targeted brain stimulation primarily in the periaqueductal gray (Panksepp 1998; Panksepp et al. 2017), although he bases this view primarily on animal experiments (rat). However, he arrives at a different classification than Ekman and distinguishes six *basic emotional systems*, namely *seeking/expectancy*, *rage/anger*, *lust/sexuality*, *care/nurturance*, *panic/separation*, and *play/joy*.

In contrast to this "modular" view of emotions, emotion researchers such as James Russell, David Watson and Auke Tellegen, but also the neurobiologist Edmund Rolls, argue that emotions are doubly "polar". According to this view, emotions differ on one axis by their valence (positive-pleasant vs. negative-unpleasant) and on the other axis by the strength of arousal (low vs. strong arousal; cf. Russell 2009).

Another classification of emotions is presented by the American emotion researchers Andrew Ortony, Gerald Clore and Allan Collins (cf. Clore and Ortony 2000), which is also followed by the Swedish researcher Arne Öhman (Öhman 1999). According to Ortony, Clore and Collins, emotions differ from affects in that they involve an evaluation of *goals, standards* and *attitudes*, which is not the case with affects and moods. According to these authors, emotions are always *intentional*, i.e. directed towards a goal.

While many authors regard affects and emotions on the one hand and cognitive performance on the other as independent, albeit interacting, mental states, Clore and Ortony are staunch advocates of a *cognitive theory of emotions*, as also advocated by the Swiss psychologist Klaus Scherer (Scherer 1999). For them, emotions are evaluative states (*appraisals*) and always have a cognitive component, in contrast to affects. They refer, whether consciously or unconsciously, to the grasping of the *meaning of* a situation or an object.

6.1.3 Unconscious Emotions and Conscious Feelings

There are numerous studies on the specific processing and effect of unconsciously perceived stimuli and stimulus situations on the limbic-emotional system (▶ Sect. 6.1.4). For example, subjects were studied who had a strong fear of snakes but not of other animate or inanimate objects. In them, a very brief (i.e., 30 ms long) and *masked* (i.e., flanked by two longer presented neutral pictures) presentation of snake pictures led to strong vegetative fear responses, although the fear-inducing pictures were not consciously perceived. This was not the case for these subjects with images that were not frightening to them. This indicates that the subjective threatening nature of the stimulus was *recognized unconsciously*. Similar results were obtained in experiments in which subjects were fear-conditioned to certain objects such as spiders, snakes or even neutral faces with the aid of a mild electric shock. When these objects were presented in a mask, the subjects showed marked vegetative responses. Similarly, in a visual search task, subjects who had been conditioned to spiders, snakes, or other objects as fearful objects recognized such objects more quickly when they were embedded in neutral or positive objects (flowers or mushrooms). The latter shows that in the domain of unconscious percepts, the *recognition of threatening stimuli* has priority over the recognition of neutral or positive stimuli. In this context, Öhman speaks of an *automated sensitivity to threats* (Öhman 1999).

6.1.4 The Neurobiological Basis of Emotions

Emotions are based on the activity of centers of the limbic system (◘ Fig. 6.1), which is described in detail in ▶ Chap. 2. Unconscious emotions are generated in sub-

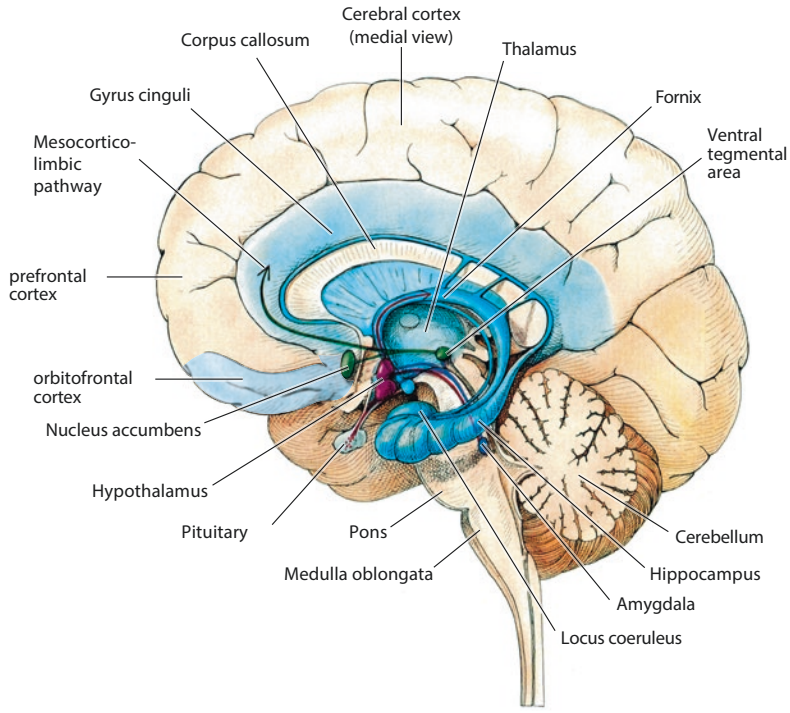


Fig. 6.1 Median view of the human brain with the most important limbic centers (blue). These centers are sites of affect generation, of predominantly positive (nucleus accumbens, ventral tegmental area) and predominantly negative or strongly moving feelings (amygdala), of memory organization (hippocampus), of attention and consciousness control (basal forebrain, locus coeruleus, thalamus), and of control of vegetative functions (hypothalamus). (Modified after Gershon and Rieder 1992)

cortical centers of the limbic system; the conscious experience of these emotions as a subjective emotional state requires the additional activation of cortical areas.

The American neurobiologist Joseph LeDoux has dealt extensively with the relationship between unconscious and conscious processes in the context of his studies on fear conditioning, primarily in rodents (Fig. 6.2). His starting point is the well-known fact that we usually react very quickly to a negative event with certain reactions (defence, flight, attack) before we have even recognised more precisely the event that triggered this reaction (LeDoux 1996). LeDoux has summarized this in a popularized model of two pathways of fear- and anxiety-related information, which assumes, on the one hand, a "fast", unconscious pathway that ends in the amygdala via the dorsal thalamus, and, on the other hand, a "slow" conscious pathway that also moves via the dorsal thalamus, but then to sensory and finally associative-limbic cortical areas (LeDoux 1996).

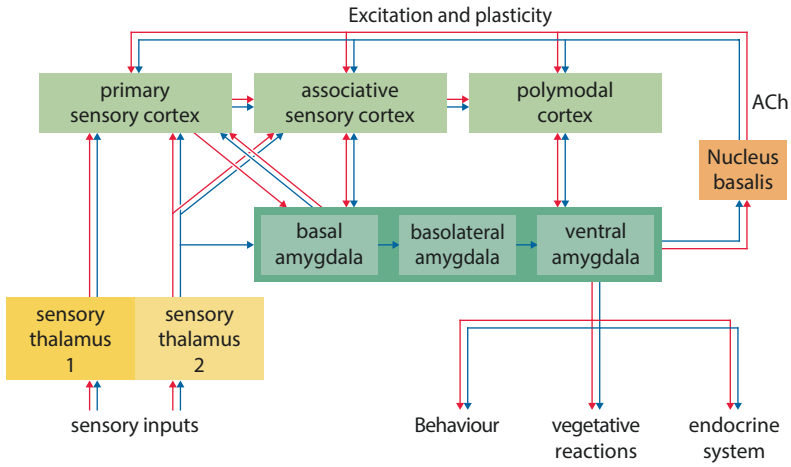


Fig. 6.2 LeDoux's model of two fear-conditioning paths and its correction. The connectivities proposed by LeDoux are shown with blue arrows, those of Pessoa and Adolphs with red arrows. According to LeDoux', auditory stimuli proceed from the inner ear via the brainstem to the thalamus and from there via the unconscious "fast" pathway directly to the amygdala (sensory pathway 2), where association with other stimuli (e.g., electric shock) occurs. Also from the thalamus, in the "slow" pathway (sensory pathway 1), signals go to the primary and secondary auditory cortex and to the associative cortex, where they are further processed until they become conscious. These conscious processes then have a feedback effect on the amygdala and other subcortical areas. According to Pessoa and Adolphs, in humans there is no direct thalamic pathway to the amygdala, rather it receives "rapid" descending inputs from primary sensory cortical areas. ACh = acetylcholine-mediated input from nucleus basalis to cortical areas. Further explanation in the text

6

Model of the Two Processing Paths

According to neurobiologist Joseph LeDoux's model, there is a "fast" and a "slow pathway" in the perception of threatening stimuli (Fig. 6.2). According to LeDoux's original model of auditory fear conditioning—based on experiments on rats—auditory stimuli travel from the inner ear via the brainstem to the thalamus and from there via the unconscious "fast" pathway directly to the amygdala, where the association with other stimuli (e.g. electric shock) takes place. Also from the thalamus, in the "slow" pathway, signals go to the primary and secondary auditory cortex and to the associative-limbic cortex, where they are further processed until they become conscious. These conscious processes then have a feedback effect on the amygdala and other subcortical areas. LeDoux has also extended this model to humans and to visual fear conditioning. However, the fast unconscious pathway seems to be designed differently in humans (as well as in other primates), where no direct sensory connections from the thalamus to the amygdala are found (cf. Fig. 6.2).

The neurobiologists Pessoa and Adolphs (2010) have pointed out that in humans, unlike the rat, LeDoux's object of study, there is no fast sensory thalamoamygdalar pathway. Rather, the "fast" pathway in humans and other primates basically runs from the thalamus first to the primary sensory cortex areas, which in turn have a direct connection to the basolateral amygdala in addition to pathways that draw to associative cortex areas (◘ Fig. 6.2). However, the notion of a fast and unconscious and a slow and finally conscious processing pathway still seems justified.

The unconscious emergence of emotions is predominantly a matter of the basolateral amygdala and the mesolimbic system. Appetitive behaviour, i.e. the pursuit of reward, is predominantly associated with activation of the nucleus accumbens, while the processing of aversive stimuli, i.e. the cessation or avoidance of pain and disappointment, mostly involves activation of the amygdala and the habenula.

Like all events in the brain, emotions thus basically arise *unconsciously in the* first instance (LeDoux 1996, 2017). The reason for this is that consciousness necessarily requires an unconscious run-up of 200–300 ms, within which certain "wake-up stimuli" from the reticular formation of the brain stem and unconscious excitations from the subcortical limbic system arrive in certain parts of the cerebral cortex and cause excitations there. They could, for example, cause the neurons that are excited there to become synchronously active (Dehaene 2014; see also ► Chap. 8).

The conscious experience of feelings arises in cortex areas belonging to the upper limbic level (see ► Sect. 6.3 on personality, see ► Chap. 5). On the one hand, these limbic cortex areas receive their own input from the subcortical and cortical sensory centers and associative areas. On the other hand, they receive massive inputs from the hypothalamus, the septum, the amygdala, and the mesolimbic system (VTA, nucleus accumbens). Through these ascending connections, the "unconscious" controls our conscious emotions (Roth and Strüber 2018). Moreover, the cortical limbic areas send massive outputs back there (Pessoa 2017). Through these retrograde connections, emotions can be consciously or unconsciously adapted to the situation at hand.

The *orbitofrontal cortex* (OFC), together with the *ventromedial prefrontal cortex* (vmPFC), is concerned with the detailed and contextual evaluation of our behavior and its consequences (i.e., prospect of reward or fear of loss) and, through this, with the control of our decisions, social behavior, morals and ethics, and, in general, with the regulation of our emotions. This also involves the ability to restrain strong emotions and impulses, which originate primarily in the hypothalamus, the amygdala, and the mesolimbic system, and not to let them overwhelm us (cf. ► Chap. 2).

A limbic area on the inner side of the cerebral cortex is the *anterior cingulate cortex* (ACC). Its dorsal part deals with internally directed (i.e., *top-down*) attention, error detection, assessing the risks of our behavior according to success and failure, while its ventral part deals with our own perception of pain and with feeling the suffering of others, i.e., *empathy* (Lavin et al. 2013; Misra and Coombes 2014).

At the transition between the frontal, parietal and temporal lobes lies—deeply sunken—the *insular* cortex. It has to do with taste, which, as is well known, together with smell, is very close to feelings, with pain perception and, in this context, just like the ACC, with empathy, namely the perception of pain in others (Decety and Michalska 2010), but also with one's own emotional pain in the case of humiliation, embarrassment and exclusion (Eisenberger et al. 2003; Singer et al. 2004, 2009; Eisenberger 2012).

The *hippocampus* plays an important role in the interaction of cognitive and emotional contents of the memory (◘ Fig. 6.1).

It is the *organizer of* the *declarative memory* that is capable of consciousness and can be formulated in language, i.e. it controls both the "reading in" and the "retrieval" of contents of long-term memory. On the one hand, it is under the influence of the entire associative cortex. On the other hand, the hippocampus receives inputs from the amygdala, the hypothalamus and the mesolimbic system. Via these inputs from the subcortical limbic system, unconscious emotional and motivational processes strongly influence the encoding and retrieval of memory content (Bocchio et al. 2017). Here, the interaction between hippocampal pyramidal cells and GABAergic interneurons, expressed in high-frequency discharges, seems to play an important role (Pastoll et al. 2013).

6.1.5 The Chemistry of Emotions

Feelings as consciously experienced emotions are always linked to the release of certain substances in the brain (Roth and Strüber 2018). *Positive* feelings such as contentment, happiness, joy, euphoria and ecstasy are caused by the release of a number of very different substances such as the neurotransmitter or modulator serotonin, which tends to calm and relax, "brain-own" (endogenous) drugs such as endorphins, enkephalins and endocannabinoids, which produce joy, pleasure and euphoria, and hormones or neuropeptides such as prolactin and oxytocin, which convey a sense of social well-being ("attachment"). Most of these substances also have *analgesic* and stress-reducing functions. These substances are produced in different nuclei of the hypothalamus and in the pituitary gland as well as in the raphe nuclei of the brain stem (serotonin) and are released in other limbic centres, especially in the amygdala, the mesolimbic system and the limbic cortex.

Negative emotional states are also triggered by very different neuropeptides and hormones. For example, the neuropeptide substance P generally mediates pain sensations and increases arousal, aggression and male sexual behavior. Vasopressin increases blood pressure and, in males, sexual appetence behavior and aggression, as does substance P. Cholecystokinin can trigger panic attacks, and corticotropin-releasing hormone (CRH) triggers feelings and reactions of stress and, in higher doses, fear and anxiety. The neurotransmitter adrenaline/norepinephrine increases general alertness, produces a general feeling of threat at higher doses and supports the consolidation of memory content (Valentino and van Bockstaele 2008).

These substances have a partly promoting, partly inhibiting effect on each other and occur in the most diverse combinations. They can be regarded as the "labels" of the results of limbic evaluation and conditioning processes and as reinforcers of their behavioral relevance. This is thought to occur primarily via the recursive interaction between the amygdala, nucleus accumbens, ventral pallidum, and hippocampus on the one hand, and the aforementioned limbic cortical areas on the other (Pessoa 2017).

Emotions and Brain

In contrast to cognitive functions, emotions have a close connection with physical states and with certain behavioral reactions (appetence and aversion). As *affects*, they are associated with basic biological needs such as food intake, defensive and sexual behavior, and brood care, and as *strong experiential states* such as anger and enthusiasm, they accompany the various attack, defense, and flight responses as well as sexual activities—i.e., our basic majority innate modes of response.

In addition, there are a number of "basic emotions" that seem to be common to all people and are associated

with certain positive or negative experiences within the framework of classical conditioning. The number of such basic emotions is controversial—estimates range from five (e.g., joy, fear, surprise, disgust, and sadness) to 15. The extent to which they exist independently as fixed modules or combine with each other, or whether they can be arranged in a double polar fashion (low vs. high arousal and positive vs. negative), is equally controversial. Generally accepted, however, is the interpretation of emotions as the results of behavioural evaluation (*appraisal*), i.e. the assessment of whether something has gone well or badly from the organism's point of view, and a resulting orientation of future behaviour in the form of wishes, goals and expectations, or the ending or avoidance of negative events. In this sense, most emotions form the basis of *action tendencies*, i.e. motivation.

Emotions initially arise unconsciously as excitations of subcortical brain centers. Often, but not always, these unconscious excitations are accompanied by a conscious feeling, which requires activation of limbic cortical areas and is much more detailed.

In the generation of emotions, activities of the subcortical and cortical limbic areas in the brain are associated with the release of certain neuromodulators, neuropeptides, and neurohormones, e.g. brain-derived opioids and cannabinoids, serotonin and oxytocin, which induce calming or positive sensations, or substance P, vasopressin, or high doses of cortisol, which induce distressing, painful, or other unpleasant sensations such as disappointment (Roth and Strüber 2018).

6.2 Motivation

Motives are mental drive states for things that do *not* run automatically, but must overcome a certain threshold or certain resistances. The higher the resistance, the stronger the **motivation** for a certain action must be. But what is it that drives us?

> The term **motivation** describes the nature, direction and duration of a behavioural drive. Such behavioural drives are called "motives". A distinction is also often made between *unconscious* motives and *conscious* goals. They are usually accompanied by positive (appetitive) and negative (aversive) feelings.

The answer of motivational psychology is that people strive to bring about events that stimulate *positive* (appetitive) feeling states and to avoid those that lead to *negative* (aversive) feeling states (cf. Weiner 1986; Kuhl 2001; Neyer and Asendorpf 2018). This is called *affect optimization* in motivational psychology. It is meant to express that everyone strives to do maximally well under the given circumstances, i.e., to experience pleasure and joy, to have fun, to be in a good mood, to be optimistic about the future, etc. This usually means at the same time that he tries to avoid pain and negative emotional states (Puca and Langens 2005).

The striving for positive emotional states, mostly due to rewards of some kind, is of course not always equally strong, but depends on many factors, such as the type and attractiveness of the reward, its sustainability and expectability or the uncertainty of its achievement or occurrence, the effort that must be made, and many others. The same applies, of course, to aversive behaviour.

6.2.1 Psychological Motivation Models

In motivational psychology, a distinction is usually made between *biogenic* motives, which are part of our biological equipment, such as the satisfaction of needs in the form of hunger, thirst and sexuality, and *sociogenic* motives. Here, four motive domains in particular are mentioned, namely *attachment*, *intimacy*, *power*, and *achievement* (cf. Heckhausen and Heckhausen 2018; Neyer and Asendorpf 2018). However, this distinction is not particularly strict, as all sociogenic motives, in order to be effective, must ultimately be linked to biogenic motives.

Attachment is the pursuit of social closeness, i.e. security, friendship and affection. This motive can also have negative effects, because people who are dominated by it often feel a fear of losing connection, i.e. rejection and disregard or the end of close social relationships. This is often accompanied by the personality trait "neuroticism", i.e. increased anxiety and ego weakness, which in turn may have its roots in a deficient attachment experience (► Sect. 6.3). The *intimacy* motive, on the other hand, is found predominantly in extraverted, i.e. positive-minded individuals who themselves radiate trust, warmth and reciprocity. They are, for example, typical "listeners". Presumably this goes hand in hand with high oxytocin levels. Negative feelings can also occur in connection with the intimacy motive, for example as fear of distance and loneliness. The motive *power* is characterized by the striving for status, influence, control and dominance. Characteristic here is the connection with an increased level of testosterone—interestingly, this is more evident in women than in men. Testosterone levels are positively coupled with the release of dopamine ("do something!") and negatively coupled with serotonin ("it's good the way it is!"). The commonly suspected link between testosterone and aggression is only significant in violent offenders and appears to occur as a result of an interaction with the cortisol system (Roth and Strüber 2018). The pursuit of power is often accompanied by the fear of losing power and control (Neyer and Asendorpf 2018).

The *achievement* motive is complex and is expressed in the need to do things well or better, to surpass oneself and others, to master difficult tasks, to start something new, to conquer things, to overcome obstacles and to increase status. The achievement motive is coupled with curiosity. However, fear of failure also occurs with it (Heckhausen and Heckhausen 2018).

Types Motivation

A distinction is made between biogenic motives, i.e. the striving to fulfil basic biological needs, and sociogenic motives such as the striving for achievement, power, closeness and intimacy. Often these motives are coupled with fear of loss of achievement, power, rejection, and distance. The achievement motive is particularly well studied in motivational psychology. Here, a distinction is made between individuals who are confident of success and those who are fearful of failure, who differ significantly in the nature and attainability of their goals.

Many psychologists have dealt intensively with the achievement motive, e.g. the American psychologist J. W. Atkinson. In his "expectation-value model" Atkinson saw the *need for achievement* as a fundamental human motive and in this context dealt with the question of what goals a person strives for in order to succeed and at the same time avoid failure (Atkinson 1964). The product of this, according to Atkinson, then determines a person's performance behavior. However, today Atkinson's model is perceived as too simplistic (Myers 2014).

The American social psychologist B. Weiner, a student of Atkinson, has tried to combine various so-called attribution theories, i.e. attempts to explain motivational behaviour on the basis of certain preconceptions, with Atkison's expectation-value model. In this context, two personality types are distinguished. The first are the *success-assured*: they have a positive basic mood and generally set themselves realistic goals and moderately difficult tasks, i.e. those which they can achieve with some effort. They generally attribute successes to themselves. Persons exhibiting *fear of failure*, on the other hand, show a negative mood and usually choose either goals that are too high, which they do not believe they can achieve anyway, or goals that are too low, the achievement of which does not give them a real feeling of reward. They fear failure rather than looking forward to success (Weiner 1986).

6.2.2 Congruence and Incongruence of Motives and Goals

In motivational psychology, a distinction is often made between motives and goals (cf. Puca and Langens 2005). According to this, motives are *unconscious*, whereas goals are *conscious* drives for action. If we follow this distinction, we can say that motives are determined by both phylogenetic and attachment-related drives to act acquired in early childhood, whereas goals are determined by drives that arise in later childhood, adolescence, and adulthood as a result of conscious experiences. Goals are shaped in particular by *ideas* about states to be achieved.

While motives are deeply and unconsciously rooted in the personality, goals are consciously processed. At the level of consciousness, we speak of *extrinsic* and *intrinsic* goals. Extrinsic goals are those that consist of material, e.g. financial, incentives or social incentives such as recognition, influence and power. Intrinsic goals, on the other hand, are those goals that correspond to personality development and are correspondingly self-rewarding. According to the well-known motivation theory of Deci and Ryan (1985), the main characteristics of intrinsic motivation are striving for competence, for inclusiveness, and self-determination/autonomy. Other authors give as examples of intrinsic rewards an increase in self-efficacy, the feeling of being better than others, or contributing to an important cause. According to Di Domenico and Ryan (2017), intrinsic motivation best predicts the traits of achievement, competence, and autonomy, and thus social and career success.

Conflicts or "**incongruities**" can arise between motives and goals. This can already occur at the level of unconscious motives (lower and middle limbic level, ▶ Sect. 6.3), for example between the striving for attachment and the striving for independence, but also between motives and goals (lower and middle limbic level vs. upper limbic and cognitive level) such as the longing for attachment and a professional striving for success. A person may be dissatisfied with a career chosen for external, e.g., material, reasons and may mourn his or her childhood dream of becoming an actor. This incongruence can manifest itself in increased psychological stress (Grawe 2007).

Congruence and Incongruence of Motives and Goals

Already at the lower unconscious level of the personality, conflicts can arise between different drives such as the search for attachment and the striving for autonomy, but also between unconscious motives (such as the striving for closeness) and conscious goals (such as the will to make a career). Such incongruities often lead to psychological conflicts and even serious mental illness. It is one of the main goals of psychotherapy and coaching to eliminate such incongruencies.

Congruence of motives and goals is the prerequisite for what the Canadian-American psychologist Albert Bandura (born 1925) called *self-efficacy*, namely the subjective assessment that the achievement of goals can be influenced by one's own behaviour (Bandura 1997). Self-efficacious people show *persistence*, i.e. a tenacity in the pursuit of goals. *Avoiders* are the opposite: they see obstacles not as a challenge but as a threat and a danger of failure. Persistence is not the only prerequisite for self-efficacy, however; the other is *reality orientation*. Indeed, one can be very persistent in pursuing a particular goal without realizing that one will never achieve that goal or that this goal is not at all as rewarding as it looked. Reality orientation means being able to assess which effort is worthwhile for which goal (Neyer and Asendorpf 2018).

6.2.3 The Neurobiological Basis of Motives and Goals

Some motives, especially those for securing our biological existence, are genetically determined, but the majority are based on learning processes that are also part of the development of the individual personality (► Sect. 6.3). In connection with the already mentioned unconscious and conscious *evaluation*, the brain determines whether and in what way certain events or one's own actions have positive or negative consequences. This is then stored in the memory of experience and forms the basis for the orientation of future motives.

At the unconscious middle limbic level (► Sect. 6.3), numerous centers are involved in these processes, including the basolateral amygdala, lateral habenula, ventral tegmental area (VTA), nucleus accumbens, ventral pallidum, and dorsal raphe nucleus. The result of this cooperation is transmitted to the dorsal striato-pallidum as a subcortical coordination center for actions. In the above-mentioned centers, especially in the VTA and in the nucleus accumbens/ventral striatum, there is a variety of neurons that process quite different portions of unconscious action planning and, in their action on cortical areas, also become the basis of conscious action planning.

Central aspects concern, on the one hand, the distinction between the subjective positive or negative state of experience, i.e. pleasure (*liking*) and displeasure, on the one hand, and the striving to attain or avoid such states of experience (appetence and aversion) on the other (Berridge and Kringelbach 2015). Both functions are based on different neuronal systems, which usually interact with each other, but can also act independently of each other.

The occurrence of pleasure states in reward situations is primarily linked to the release of endogenous opioids (endorphins and enkephalins) and cannabinoids, which evoke corresponding feelings by binding to different receptors (mostly mu and kappa receptors or CB1 receptors). This occurs in so-called *hedonic hotspots*, i.e., small areas in different limbic centers such as the nucleus accumbens, amygdala, ventral pallidum, VTA, and cortical limbic areas (e.g., OFC,

insular cortex; Berridge and Kringelbach 2015; Wenzel and Cheer 2018). These *hedonic hotspots* are spatially separated from *coldspots* that counteract positive experiential states, for example, in the nucleus accumbens, VTA, and ventral pallidum.

The second effect of endogenous opioids and cannabinoids is the inhibition of GABAergic interneurons in the VTA, which in turn inhibit dopaminergic neurons. By *inhibiting* these inhibitory neurons, the dopaminergic neurons in the VTA are activated and can influence the nucleus accumbens, ventral pallidum, and other behaviorally relevant limbic areas via their efferents. Via this effect, endogenous opioids and cannabinoids released in reward situations can trigger appetitive behavior. Aversive stimuli, on the other hand, have a reinforcing effect on inhibitory GABAergic interneurons and decrease or block the activity of dopaminergic neurons. The lateral habenula, which is under the influence of both the amygdala and limbic cortical areas (e.g., OFC, mPFC), plays an important role in mediating aversive stimuli with its projection to caudal parts of the VTA (Baker and Mizumori 2017).

According to a model developed by W. Schultz and colleagues, dopaminergic neurons signal two different stimulus classes with their activity (Stauffer et al. 2016). A first and fast response occurs to any kind of *salient* stimuli regardless of their reward character (*saliency response*), which directs the brain's attention to these stimuli. Only a second, slower response is reward-specific and signals whether a particular reward expectation will be fulfilled or is stronger or weaker than expected—somewhat confusingly called "*prediction error*" (Schultz 2016), a better term would be "deviation from expectation". Normally, dopaminergic cells are uniformly active at low frequency (*tonic* activity). The unexpected receipt of a reward (i.e., a high positive deviation from expectation) leads to an additional volley of action potentials, i.e., a *phasic* response. If it is learned that a particular stimulus always precedes a reward and thus predicts it, then the phasic dopamine response occurs shortly after the announcing stimulus, but not at the time of the reward. This signals *reward anticipation*. However, if the reward fails to occur despite being announced, then tonic dopamine activity falls *below* the normal tonic level at the time of the missing reward (Schultz 2007).

In addition to the occurrence and eventual degree of reward, certain dopaminergic cells signal the degree of *uncertainty of* a reward (Fiorillo et al. 2003). This is encoded by a slow and moderate activation that occurs between the first cue of a reward and the time of its occurrence and is higher the greater the uncertainty about whether the cue stimulus and the accompanying phasic dopamine response actually herald a reward. Thus, the target cell receives another signal: a fast and high dopamine release informs that a reward is expected, a slow, moderate dopamine release signals *uncertainty* about whether the reward will actually occur.

However, *risk awareness* also plays a role here: If the reward value is high and the uncertainty about the occurrence of the reward is also high, then cautious individuals with a high risk awareness feel no motivation to act, whereas particularly risk-seeking individuals react to this pattern with a great willingness to behave. For them, the slow dopamine signal of uncertainty itself has a rewarding effect and reinforces risky behavior. This explains, for example, why some individuals are willing to wager large amounts in gambling even though the uncertainty about a possible win is extremely high (Fiorillo et al. 2003).

Some dopaminergic cells also signal *aversive* events such as punishment or reward deprivation via a slow, sustained reduction in spontaneous activity due to the influence of the aforementioned inhibitory (GABAergic) neurons in the VTA (Luo et al. 2011). Such signals reinforce withdrawal behavior and lead to avoidance of a particular stimulus.

However, there is increasing evidence that there are dopaminergic neurons in the VTA that are *directly* excited by aversive stimuli (Holly and Miczek 2016). These influence neurons in medial areas of the nucleus accumbens via their terminals, which then mediate the occurence of aversive stimuli (De Jong et al. 2019).

With regard to the expectation of rewards, it has also been shown that serotonergic neurons in the dorsal raphe nucleus are significantly involved in the action of dopaminergic neurons (Fischer and Ullsperger 2017). For its part, the dorsal raphe nucleus is under cortical (medial PFC) and subcortical control (lateral habenula), among others, and projects massively to the VTA, among many other brain regions. The serotonin release that takes place leads to increased activity of the dopaminergic neurons there. It is possible that they are particularly involved in the detection of surprising stimuli (Fischer and Ullsperger 2017).

Parallel to subcortical processing, information is transmitted via the mesocortical pathway system to the upper limbic and cognitive levels, where conscious desires, goals and concrete intentions arise. This primarily involves the orbitofrontal, anterior cingulate, ventromedial, and ventrolateral prefrontal cortex, which are responsible for conscious intentions to act, the dorsolateral prefrontal cortex, where mental action planning occurs, and the posterior parietal cortex, which is responsible for the spatial embedding of behaviors. Of particular importance are the functions of the orbitofrontal and ventromedial cortex, which contain neurons that also encode the social desirability or non-desirability of desires and intentions. This occurs in interaction with the insular cortex, which, like the nucleus accumbens, signals physical pleasure and physical pain via hotspots and coldspots (Berridge and Kringelbach 2015).

Dopaminergic Reward System

The limbic evaluation system classifies everything we experience or do as positive or negative. This results in the tendency to repeat what evoked positive states or feelings (appetence) and to avoid negative things (aversion). The interaction between the amygdala, lateral habenula, nucleus accumbens and VTA plays the decisive role here, whereby the amygdala in humans via the lateral habenula is more "responsible" for the negative, surprising or strongly emotionalising, while the nucleus accumbens and VTA, with the involvement of the serotonergic dorsal raphe nucleus, are more "responsible" for the positive, rewarding. Positive experiences result in reward expectations, which are represented in dopamine signals in the VTA and nucleus accumbens. These encode different aspects of reward occurrence and expected reward such as type, strength, probability of occurrence, effort, risk and uncertainty. However, there are also dopaminergic neurons that directly encode aversive stimuli.

Thus, a complex network exists in the brain that registers the occurrence of positive and negative stimuli in a finely graduated manner and becomes the basis of motivation in the form of appetitive or aversive behavior. In this process, all conceivable aspects of possible action goals are taken into account, such as the strength and the temporal and spatial attainability of a goal, its sustainability, the effort to be expended, and the certainty or uncertainty of its occurrence. Schultz and colleagues were able to show

that, based on the activity of this network, a behavior is generated that can be interpreted as "purposive" (Pastor-Berniera et al. 2017).

6.2.4 How Is Motivation Translated into Behaviour?

Motivation, we have heard, is the formation of unconscious motives and conscious goals, and thus of behavioral tendencies. But how does the actual conversion of such tendencies into behavior take place in the brain?

It was long believed that the dorsolateral prefrontal cortex (dlPFC), located in the upper lateral frontal brain, as the seat of logical operations, was the "supreme decision-making center", but it turned out that behaviorally relevant decisions are made by a complex network of brain centers. The dlPFC maintains goals in the process and is something of a "rational advisor" to which, figuratively speaking, the actual action-controlling cortical and subcortical brain centers can, but need not, listen. The dlPFC might not exert any direct control function at all, because it has only sparse connections to the decision centers, while they exert a strong influence on it (Ray and Zald 2012). This explains why reason and rationality often have little effect, while stronger and seemingly irrational emotions can carry us along.

As illustrated, there are unconscious- or conscious-emotional and conscious-rational operating decision-making instances. The unconsciously operating instance includes the hypothalamus, the septum, the PAG, the amygdala and the nucleus accumbens at the lower and middle limbic level; they comprise partly innate and partly early acquired motives. If the activity of these centers remains, we act *without knowing why*. The conscious instances are represented by cortex areas on the upper limbic level. These include the intuitive behavioral tendencies, often called "gut feelings." The third instance is located at the cognitive-linguistic level, primarily in the dlPFC, and includes the rational-thought evaluation level. All three instances mediate motives and the goals, between which there are often multiple "battles" in the sense of a clearing of neuronal excitations until the dominance of one motive or goal is established. As mentioned above, the rational level has the weakest voice—unless the rational arguments are supported by emotional states—and the unconscious motivational level the strongest voice—unless the conscious level can offer strong counter-arguments, for example in the form of imagined losses or unpleasant social consequences (Ray and Zald 2012).

The convergence center of this "power poker" is the dorsal striatum, which is our action memory. This is where all our actions are stored that were once successful. All unconscious and conscious intentions to act must be aligned with this memory. The dorsal striatum is connected by many recursive pathways to both the cortical and subcortical decision centers. It is in these circuits that the sometimes short, sometimes long process takes place in which intentions and desires become a concrete willingness to act, resulting in either a volitional decision or a pressure to act (or both) (Ashby et al. 2010). These findings of neuroscience substantially contradict the still highly regarded "Rubicon model" of decision-making as developed by Heckhausen and Gollwitzer (1987) decades ago, in which *unconscious* deliberation and decision-making processes do not occur at all.

Motivation

Motivation is understood to be psychological drive states that are directed towards the fulfilment of biological, individual and social needs. The former result from genetic drives, the latter from unconscious or conscious experiences of a posi-

tive and negative nature that guide our further actions in such a way as to seek the repetition and more detailed exploration of positive states (appetence) or the termination or avoidance of negative states (aversion). In the brain, this is controlled in an unconscious way by subcortical limbic centers such as the amygdala, nucleus accumbens, and VTA, and in a conscious way by limbic cortex areas such as the orbitofrontal, ventromedial, and insular cortex.

6.3 Personality

Our experience teaches us that no two people are alike, that everyone is somehow different from others in terms of how they look, think, feel and act. At the same time, we also observe that despite all variability, there are *basic patterns of feeling*, *thinking* and *acting* that we can often use to describe people quite effectively.

However, these are not regularities in the strict sense, but *dispositions* which we expect a person to have with varying degrees of probability on the basis of certain prior knowledge and prior experience. A sufficiently high degree of expectability of the human personality and the resulting action is the basis of social coexistence, whereas too much rigidity of personality as well as too much variability would make social life impossible.

6.3.1 How Do We Capture a Person's Personality?

Even in antiquity, people thought about how best to assess the personality and psyche of a person. The best known of these is the "doctrine of the temperaments", which goes back to Hippocrates and Galenos and divides people into four personality types: choleric, melancholic, phlegmatic and sanguine. Modern personality psychology, on the other hand, does not look for rigid types, but for the existence of individual, statistically well-definable (if possible, non-overlapping) personality traits that are found in stronger or weaker forms in all people. Accordingly, the individual personality of a person consists of a *unique combination of* such characteristics (for an overview, see Stemmler et al. 2016; Neyer and Asendorpf 2018).

The approach commonly used in personality psychology is usually based on the so-called lexical method, which was first developed in the 1930s by the psychologists Allport and Odbert (Allport and Odbert 1936). In this process, starting from everyday psychology, one takes from common lexicons all conceivable vocabulary describing human characteristics. There are many thousands (in English almost 18,000) of such words, which, however, overlap considerably in their meaning. By repeatedly combining overlapping characteristics, usually with the help of so-called **factor analysis**, we arrive at fewer and fewer overlapping personality attributes, until finally a few basic characteristics emerge. These should be maximally free of overlap (mutually "orthogonal").

Factor Analysis

is a statistical method that is used to derive a few basic factors from a set of observable characteristics that exist as independently as possible and are as free of overlap ("orthogonal") as possible. This procedure is used for data and dimension reduction. In psychology, for example, it is used to identify the basic characteristics of a person's personality.

The personality tests in use today are usually based on three to six basic factors (cf. Neyer and Asendorpf 2018). The well-known "Big Five" personality test was

developed by the psychologists Costa and McCrae in the 1980s and 1990s, building on preliminary work by the German-British psychologist Hans-Jürgen Eysenck (Costa and McCrae 1989, 1992). In the meantime, a revised version (NEO-PI-R) is available. A German version of this version was published by Ostendorf and Angleitner (2004). In this test, the basic factors are extraversion, neuroticism, agreeableness, conscientiousness and openness/intellect.

> The "NEO-PI-R" is the revised version of the Five-Factor Personality Test by Costa and McCrae. A German version was presented by Ostendorf and Angleitner in 2004. With 240 items, this test attempts to capture the basic personality traits of human beings. A more differentiated view of the five main factors is to be achieved by a total of 30 facets.

Let us look at the five basic factors. Each of these basic factors can be present in different degrees of expression—usually this is indicated in the form of a five-point *Likert scale* from "strongly pronounced" to "weakly pronounced" or "not at all" with three intermediate levels. Let's take a look at these "Big Five":

- *Openness-Intellect* denotes, in its strongest form, the characteristics broadly interested, imaginative, intelligent, original, inquisitive, intellectual, artistic, clever, inventive, witty, and wise, and, in its weakest form, the characteristics ordinary, one-sidedly interested, simple, without depth, and unintelligent.
- The factor *Conscientiousness* includes the traits organized, careful, planning, effective, responsible, reliable, accurate, practical, cautious, deliberate and conscientious in strong expression and the traits careless, untidy, reckless, irresponsible, unreliable and forgetful in weak expression.
- The factor (Extraversion) *Extraversion* in its strong expression includes the traits talkative, determined, active, energetic, open, dominant, enthusiastic, social and adventurous and in its weak expression the traits quiet, reserved, shy and withdrawn.
- The factor *Agreeableness* denotes the traits compassionate, kind, admiring, cordial, soft-hearted, warm, generous, trusting, helpful, indulgent, friendly, cooperative, and sensitive when strongly expressed, and the traits cold, unfriendly, quarrelsome, hard-hearted, cruel, ungrateful, and stingy when weakly expressed.
- The factor (Neuroticism) *Neuroticism* refers in strong expression to the traits tense, anxious nervous, moody, worried, sensitive, irritable, fearful, self-pitying, unstable, despondent and despondent and in weak expression to the traits stable, calm and content. It should be noted that this factor has a negative-positive polarity, while the others show a positive-negative polarity.

In English, the best way to remember the "Big Five" is by the acronym OCEAN.

Personality tests of the Big Five type are commonly used to determine a person's personality in relation to his or her suitability for a particular job, whether it be a managerial position in business or government or in politics. It attempts to determine the degree to which a person is "extraverted", "neuroticistic", or "conscientious", etc. This results in a personality profile of the person in question.

6.3.2 Criticism of the "Big Five", Additions and Alternatives

Within personality psychology, the Big Five approach is not without controversy (cf. Neyer and Asendorpf 2018). One fundamental criticism concerns the fact that the Big Five are essentially taken from everyday

psychology and have no further explanatory value. Likewise, it is criticized that personality tests of the "Big Five" type usually involve self-reporting by the persons tested, which as "questionnaire psychology" is regarded by experts as not reliable, since people are generally not good at assessing their own personality, not to mention pretence. As a rule, people tend to "whitewash" their own abilities and achievements; however, neuroticistic individuals show a clear tendency to "blackwash" (cf. Myers 2014; Fletcher and Schurer 2017). It is also apparent that the five basic factors are sometimes significantly correlated with each other, which affects their discriminatory power. Indeed, Neuroticism and Conscientiousness have considerable proximity to each other, as do Extraversion, Agreeableness, and Openness/Intellect. Finally, the Big Five have not been shown to apply well to other populations and cultures, leading in part to an expansion and in part to a reduction in the number of basic factors or subfactors (*facets*) (Neyer and Asendorpf 2018).

The efforts of the British psychologist and personality researcher Jeffrey Gray were also aimed at reducing the five basic factors. Gray assumed three basic personality-related behavioral patterns, namely a "*behavioral approach system*" (BAS), at the center of which is reward orientation; a "*behavioral inhibition system*" (BIS), which is essentially characterized by passive avoidance behavior; and a "*fight, flight, and freeze system*" (FFFS) *fight-flight-freezing system*, which involves rapid, active avoidance behavior (Gray 1990). The BAS shows great similarity to "extraversion" in that it includes strong reward orientation, impulsivity, sensation seeking, as well as sociability and generally positive feelings. The BIS, in turn, has great similarity to "Neuroticism" in that it includes increased attention to negative things, rumination, anxiety, and depression. The FFFS, on the other hand, has no equivalent in the Big Five.

Definition

Proximity system	**(*behavioral approach system*, BAS) refers to reward orientation.**
Inhibition system	(*behavioral inhibition system*, BIS) refers to passive avoidance behavior.
Fight, Escape and Freezing System	(*fight-flight-freezing system*, FFFS) refers to fast, active avoidance behaviour.

Current efforts by personality psychologists are also aimed at identifying "super traits" along the lines of Gray's BAS and BIS. According to the American psychologist Colin DeYoung and his colleagues, these are *Stability* and *Plasticity* (DeYoung 2006; DeYoung et al. 2013, 2016). The Stability super trait encompasses the three Big Five traits of Neuroticism, Agreeableness and Conscientiousness, which have the core trait of risk avoidance, playing it safe to the point of absolute passivity and complete withdrawal into depression. The super trait Plasticity comprises the two Big Five traits Extraversion and Openness/Intellect, which revolve around a desire for novelty and adventure up to high-risk behavior and sensationalism.

Asendorpf and Neyer assume that people can be grouped into three *main types*, namely the *resilient*, the *over-controlled* and the *under-controlled* person (cf. Neyer and Asendorpf 2018). In this context, the *resilient* person turns out to be attentive, proficient, skilled, self-confident, fully engaged and curious. However, she may also have marked mood swings, also exhibits immature behavior under stress, loses control easily, is quick to snap, and starts crying easily. The *over-controlled* person is agreeable, con-

siderate, helpful, obedient, compliant, understanding-reasonable, has self-confidence, is self-assured, but is also aggressive and annoys others. Finally, the *under-controlled* person is lively, fidgety, does not keep to boundaries, has negative feelings, blames others, is fearful-anxious, gives in to conflicts, makes high demands on himself, is inhibited and tends to brood.

Experts agree that there are important personality traits that are not accurately captured by the Big Five. These include the trait impulsivity, which, however, has to do with very different and poorly connected sub-traits such as high plasticity and low *stability*, *urgency*, *lack of stamina*, *lack of foresight* and *low tolerance of reward deferral* (cf. Heinz and Rothenberg 1998; Heinz et al. 2011). Other authors cite traits that are not well captured by or are "cross-cutting" to the Big Five approach as: *Distress tolerance* (Chowdhury et al. 2018), *sensation seeking* or *hunger for experience* (Mann et al. 2017), *psychological flexibility* (Steenhaut et al. 2018), and *grit* (determination, commitment), by which is meant especially the persistent pursuit of long-term goals (Tucker-Drob et al. 2016; Wang et al. 2017), and *self-control* (Myers 2014). Both of the latter traits predict academic and career success better than the Big Five.

An important criticism of the Big Five model concerns the fact that it is not based on any statements about the *development of* individual personality. Indeed, certain basic personality traits are already visible at birth or shortly thereafter and are referred to as **temperament** (Thomas and Chess 1977; Buss and Plomin 1984; Blatný et al. 2015; ▶ Chap. 5). Thus, one baby or toddler is relatively calm, the other more "whiny" or even a "cry baby"; one child is open, friendly, the other more closed, difficult to approach, and so on, and these characteristics do not change significantly throughout life. Many psychologists therefore believe that temperament is essentially genetic and thus subject to the "lottery of genes or gene alleles". However, there is much evidence of a lasting influence by the prenatal environment, namely via the mother's body and brain (see ▶ Chap. 5). For this reason, the term "congenital" may only be understood as "already present at birth" and not necessarily as "genetically determined". Irrespective of this, it can be assumed that the temperament of a newborn or young child has an important function in setting the course for the further development of the personality. Thus, the caring behaviour of the primary caregivers is often unintentionally very different in the case of a calm or difficult temperament, and this can significantly influence the child's attachment experience. This, in turn, can provide the basis for the child's later attachment model, unless psychologically powerful events occur later in life (Fletcher and Schurer 2017).

Temperament

Temperament refers to basic emotional and motor characteristics of a person that appear very early, often shortly after birth, and remain relatively constant over the lifespan. They mainly concern a person's degree of sensory and emotional excitability, his or her readiness and strength to react, the degree of openness or closedness to other people and new things, the tendency to be calm or active, etc. Temperament can be determined genetically as well as prenatally epigenetically or early postnatally.

Overview

Current personality psychology is concerned with determining basic characteristics from the multitude of personality traits with the aid of statistical procedures (e.g. factor analysis) that are relatively persistent over time and as free of overlap as possible. Most models are

based on a few, usually three to six basic personality factors, which are present in varying degrees of intensity. They are mainly based on everyday psychology, and their lack of overlap is controversial. They are also based on self-report, which many experts believe is an unreliable tool. Beyond the Big Five, many authors see important personality traits such as impulsivity and attachment as not being included, while other authors try to reduce them to the two "super traits" of approach and avoidance or stability and plasticity.

6.3.3 Genetic Foundations, Stability and Changeability of Personality Traits

The question of the genetic determinacy of basic personality traits is widely disputed in personality psychology. On the basis of classical twin research, heritability values of the Big Five traits of 40–60% have been arrived at so far (Bouchard Jr and McGue 2003). Due to methodological inadequacies of twin research and more recent findings on the role of genes in the development of psychological traits, genetic studies based on so-called single nucleotide polymorphisms (SNPs) have been carried out in recent years. These showed, on the one hand, that hundreds to thousands of different genes are involved in basic personality traits and, on the other hand, that there is a much lower heritability rate of the Big Five traits.

For example, a heritability rate of only 15% was found for neuroticism, a rate of 21% for openness to experience, and no meaningful values at all for extraversion, conscientiousness and agreeableness (Power and Pluess 2015). However, these findings by no means imply that the Big Five traits or the other traits mentioned have weak genetic underpinnings, but merely that they are undetectable with today's standard genetic screening based on SNPs. In particular, the much more significant epigenetic factors have hardly been studied to date (▶ Chaps. 5 and 7).

In the popular psychological literature, opinions about the stability of personality or personality traits over the life span vary widely. While some assume a high degree of stability from childhood to old age, many popular authors assume a constant lifelong changeability, whether due to changing life circumstances or of one's own volition. However, serious research comes to a different conclusion (cf. Neyer and Asendorpf 2018). Different personality traits vary in stability: intelligence (measured by IQ) is the most stable, ranging from 11 to 69 years, while the Big Five personality traits, understood as personality profiles, have an average stability of up to 0.65 (extraversion and neuroticism). In general, the variability of personality traits is greater in childhood and adolescence, where environmental influences have a greater impact and traits experience a temporary destabilization at puberty. In early adulthood up to the age of 60–70, the traits stabilize significantly (up to 0.8), but become more variable again towards older age, mostly due to neurological degradation processes. The whole can be understood as a product of the interaction of "disposition" and "environment", with a clear tendency towards self-stabilization. As Asendorpf and Wilpers (1998) note, the ability to either influence one's own environment or to seek out the environment that suits one's own personality increases greatly with increasing age.

Certain genetic, epigenetic and early-childhood factors, especially negative ones, can *in combination* strongly influence personality development at a very early age, as long-term cohort studies, such as the well-known Dunedin study, have shown (Moffit and Caspi 2001), and can be linked to neurobiological factors. With regard to certain psychiatric disorders and antisocial behav-

iour, a very negative channelling effect may occur here that is then difficult to interrupt (see ▶ Chap. 7).

The stability of personality traits mentioned here by no means implies that people behave in a certain way across different situations. Rather, it is part of the nature of a healthy person's personality to behave, sometimes very differently, in different social contexts (Mischel et al. 1989; cf. Myers 2014). Constancy here refers to the pattern of difference in contextual behavior. Unfortunately, there is little robust empirical research on this.

6.3.4 The Neurobiological Foundations of Personality

The psychological personality typologies presented are predominantly purely descriptive and usually do not provide any deeper reasoning as to why it is precisely these basic factors that best describe a person's personality. Nor do they answer the question of *why* one person is more extraverted and another more neuroticistic. In recent years, a number of personality psychologists and neurobiologists have sought to provide a neurobiological rationale, although the results have so far been unsatisfactory (cf. DeYoung and Gray 2009; Corr et al. 2013; Di Domenico and Ryan 2017). Currently, common methods include measurements of properties of the so-called *default-mode* network (DMN), which is active when no cognitively demanding tasks are currently being processed. It is assumed here that different properties of the *default-mode* network are recognizable in different personality types. This is measured using various imaging methods, primarily fMRI and EEG. In research of this type by Toschi et al. 2018, only the Big Five trait Conscientiousness was found to be significantly related to structural and functional connectivity in the left fronto-parietal network, i.e., this trait was more strongly present the more pronounced the trait Conscientiousness was. The authors interpret this finding as an indication of increased cognitive control and behavioral flexibility. With regard to the other Big Five traits, there were no significant correlations with states of the DMN.

Another approach to linking characteristics of this network with personality traits is the determination of low-frequency oscillations in a frequency range of 0.01–0.25 Hz in total, which is usually divided into five frequency bands. Here, for the trait Extraversion, there was a significant correlation of resting activity in all five frequency bands and for Conscientiousness in frequency band 2 (0.138–0.25). The other three Big Five traits showed no significant correlation (Ikeda et al. 2017).

The application of further neurobiological methods such as the determination of brain surface morphology revealed correlations with extraversion and agreeableness and neuroanatomical properties such as surface area or thickness of certain cortical areas, which did not correspond well with previous research results and are also difficult to interpret (cf. Li et al. 2016).

Overall, it appears that the described measurements of the brain's resting activity have so far not yielded any meaningful results about the neurobiological foundations of personality traits. It can be assumed that such measurements have so far been far too crude to capture the neurobiological bases of complex personality traits. Currently, studies of the relationship between psychologically well-recorded mental states and behavioral performance, functional anatomical conditions, and neurophysiological-pharmacological processes are far more informative.

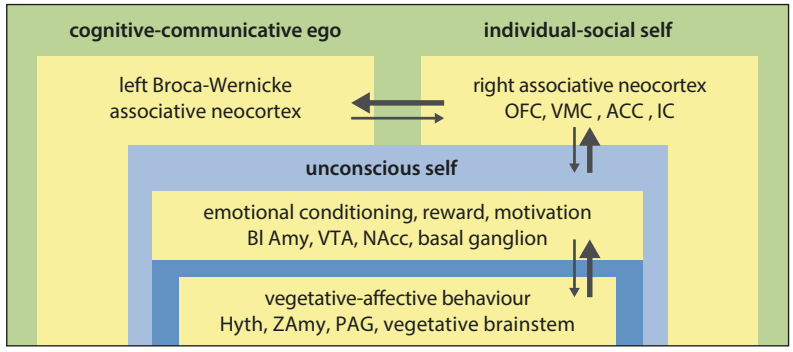
In the following, we will explain the emergence of basic personality traits on the basis of such correlations, using the four-

level model of personality already presented in ▶ Chap. 5 and the basic psychoneural systems also presented there.

6.3.4.1 The Four-Level Model of Personality

Roth and Cierpka's four-level model of personality (cf. Roth and Strüber 2018) assumes the presence of four anatomical and functional brain levels, namely three limbic levels and one cognitive level (◘ Fig. 6.3), based on a large body of neuroscientific research (cf. ▶ Chap. 2).

- The *lower limbic level* contains, through the activity of centres such as the hypothalamus-pituitary, septum, central amygdala, PAG and centres of the pons and medulla oblongata, mechanisms which serve to sustain life and fulfil primary bodily needs; but it also contains those characteristics which are considered to be part of temperament (see ▶ Sect. 6.3.2). The processes taking place at the lower limbic level are and remain unconscious; they belong to the *primary unconscious* and are difficult to change from the outside.
- The *middle limbic level*, primarily represented by the activity of the mesolimbic system (nucleus accumbens, VTA) and the basolateral amygdala, is significantly shaped by the experiences of the infant and toddler over the course of the first 3 years, with the experiences of interaction with the primary caregiver, often the mother, being particularly important. These experiences become deeply imprinted, and their influence is difficult to change, and only through targeted action. Infants and toddlers are at least partially conscious of these experiences. However, these experiences cannot be stored in the long term, because in the first years of life there is no long-term memory capable of remembering. Since Sigmund Freud, this phase has been called "infantile amnesia". It belongs to the *secondary unconscious* because of its fundamental nonrememberability.
- At the *upper limbic level*, represented by activities of the limbic cortex (orbitofrontal, ventromedial, anterior cingulate and insular cortex), those processes take place which are suitable for bringing our primary personality into harmony with the requirements of social coexistence, from the family through kindergarten and school to adulthood. Here it is a



◘ **Fig. 6.3** Roth and Cierpka's four-level model of personality. The lower limbic level of vegetative-affective behaviour and the middle limbic level of emotional conditioning, evaluation and motivation together form the "unconscious self". At the conscious level, the upper limbic level forms the "individual-social self", which is contrasted with the "cognitive-communicative self". *ACC* anterior cingulate cortex, *basal gang.* basal ganglia, *Bl Amy* basolateral amygdala, *Hyth* hypothalamus, *IC* insular cortex, *NAcc* nucleus accumbens, *PAG* periaqueductal gray, *OFC* orbitofrontal cortex, *VMC* ventromedial prefrontal cortex, *VTA* ventral tegmental area, *ZAmy* central amygdala. (From Roth and Strüber 2018)

matter of the formation of cooperativeness, consideration, patience, the ability to compromise, empathy, but also of determination, the will to assert oneself, self-efficacy, self-realisation, etc.

- At the *cognitive-linguistic level*, mediated by the activities of the frontal, temporal and parietal associative cortex, the acquisition of experience and knowledge as well as linguistic communication take place as the basis of factual-logical thinking, ideas and action planning. The emotional components of such events are added by the instances of the upper limbic level. The cognitive-linguistic level can be strongly influenced by the limbic levels, but itself only has an influence on our behavioural decisions by "addressing" emotional contents of the limbic levels.

6.3.4.2 The Six Basic Psychoneural Systems as Determinants of Personality

Personality and psyche develop on the three limbic levels mentioned above and with the involvement of the cognitive level. This occurs within the framework of the functions of six "basic psycho-neural systems", namely stress processing, emotional control and self-soothing, reward and reward expectancy/motivation, attachment behaviour/empathy, impulse control and reality sense-risk perception (see ► Chap. 5). The systems influence each other in both positive and negative ways (cf. Roth and Strüber 2018) and form a tight network of interactions. Their respective activity is associated with various personality traits.

■ Stress Management

The way a person deals with physical stresses such as illness and pain, as well as psychological stresses such as threats, challenges, disappointments and defeats, shame and exclusion, forms a basic feature of his or her personality. This trait forms very early and is essentially related to the prenatal and postnatal development of the cortisol system. Here, early aversive experiences have a clear negative effect (Fletcher and Schurer 2017). This is already evident in the very normal diurnal pattern of "basal" cortisol release. For example, individuals who are attributed with a high degree of emotional instability in the sense of "neuroticism" of the Big Five often react to waking up in the morning with a high release of cortisol. In a recent study, individual cortisol parameters were found to be less related to neuroticism and negative affect, and instead closely related to extraversion and positive affect. Indeed, the latter traits are associated with only a low morning cortisol release (Miller et al. 2016).

The actual stress-related releases of cortisol sit as "pulses" on top of the normal cortisol diurnal cycle. Apparently, the high resting cortisol release interferes with an adequate stress-related cortisol response, because neuroticistic individuals respond to a stressful situation with an attenuated cortisol response (Oswald et al. 2006).

■ Emotional Control and Self-Soothing

The psychoneural self-soothing system is closely linked to the serotonin system (primarily the 5HT1A-receptors). Similar to the stress processing system, it partially develops prenatally. Sufficient serotonin levels are important for the perception of emotional states, i.e. they promote emotion control, goal-directed behaviour and inhibit hasty reactions to possible dangers (see below). A *deficiency* of serotonin is observed in a context of continuous preoccupation with stressful stimuli. This can manifest itself in inner restlessness and, mainly in men, in impulsivity and reactive aggression (Cleare and Bond 1995).

The serotonin system is involved in almost all Big Five traits as well as negatively in the trait impulsivity. A low activity of the self-soothing system leads to the pre-

dominance of neuroticistic traits such as an increased sense of threat, low frustration and loss tolerance, brooding, anxiety and depression up to complete apathy.

Reward and Reward Expectation (Motivation)

The system of reward and reward expectancy as the basis of motivation is closely related to the dopamine system described in ► Sect. 6.2. This system develops postnatally from the first years of life until well into adulthood. It is usually associated with the trait *Extraversion* and with Gray's *behavioral activation system* mentioned above—the latter describes the individual's *reward sensitivity*.

Depue and Collins (1999) distinguish "attachment-oriented" extraversion (*affiliative extraversion*), i.e. increased sociability, in contrast to "action-oriented" extraversion (*agentic extraversion*), which is associated with the characteristics "energetic" and "success- and reward-oriented".

An increase in attachment-oriented extraversion leads to a strong need for sociability and social integration. A stronger expression of action-related extraversion, on the other hand, leads to ambition, dominance, a desire for power, and a desire for adventure and sensation. Action-related extraversion is influenced by other substance systems in addition to dopamine. In some studies, a high level of extraversion is associated with low serotonin and high norepinephrine (noradrenalin) levels (Cloninger 1987, 2000). In addition to extraversion, according to a number of studies, personality traits such as curiosity, sensation seeking, and creativity are also associated with increased release of dopamine. Highly creative individuals, for example, have a low density of inhibitory D2 receptors in thalamic nuclei that project to the prefrontal cortex (De Manzano et al. 2010), and therefore may be able to live out their ingenuity.

Attachment Behaviour and Empathy

A person's attachment behavior is also a central personality trait that is "transverse" to the Big Five, as it influences the expression of several Big Five traits. It correlates positively with traits of extraversion, agreeableness and openness and negatively with traits of neuroticism, namely anxiety and withdrawal. From a neurobiological perspective, attachment orientation is equally determined by oxytocin, endogenous opioids, and dopamine as the basis of *attachment-oriented* extraversion. Individuals with a highly active oxytocin system are often characterized by a marked sensitivity to others (Meyer-Lindenberg et al. 2011; Carter 2014). Several studies have shown that a single administration of oxytocin via nasal spray can transiently affect numerous traits. These include, for example, trust and generosity, but also negative traits such as schadenfreude. The effect of oxytocin is also dependent on the expression of the personality trait *extraversion*. In individuals with a low expression of this trait, the administration of oxytocin is associated with increased prosocial behavior and increased trust in an interaction partner. In individuals with a high expression of this trait, no comparable effect of oxytocin administration could be demonstrated (Human et al. 2016).

Impulse Control

Impulse control, like attachment behavior and sensation seeking, is "across" the Big Five and related to components of neuroticism and conscientiousness (Mann et al. 2017). Serotonin plays an important role here by contributing to emotional control and thus behavioral inhibition (Daw et al. 2002). With impulsivity, according to DeYoung and Gray (2009), a distinction must be made between active and reactive impulsivity. *Active* (or "agentic") impulsivity is associated with high scores on the trait extraversion and with seeking immediate

rewards, dominance, power-seeking, sensation-seeking, and lack of risk perception. At the same time, active impulsivity is related to high levels of dopamine and testosterone. Similarly, actively impulsive individuals have low levels of neuroticism, agreeableness, and conscientiousness.

Different from this is *reactive* impulsivity, which is associated with low serotonin levels and high cortisol and noradrenaline levels and is based, among other things, on a reduced ability to distinguish threatening stimuli from non-threatening stimuli. Similarly, a diminished capacity to regulate one's emotions occurs. This in turn brings with it a high level of insecurity and a general negative emotionality (see Depue 1995). Reactively impulsive persons are not impulsive all the time, but only in situations that appear threatening, in which they defend themselves because they see no other possibilities for action.

Sense of Reality and Risk Perception

A balanced personality includes the ability to perceive the situation in which one finds oneself appropriately and to realistically assess its relevance for one's own behaviour. In addition, there is the ability to evaluate the short- and long-term consequences of one's own actions, not to overestimate or underestimate one's own strengths, to correctly grasp the intentions of others, to recognize opportunities and risks and to take them into account in one's own actions.

This important personality trait is also not centrally contained in the Big Five, but is distributed across almost all five basic traits. A good perception of reality and risk includes, on the one hand, a balanced relationship between extraversion, i.e. positive thinking and risk-taking, and neuroticism, i.e. critical thinking and risk aversion, and, on the other hand, a balance between conscientiousness and openness/intellect. From a neurobiological perspective, this implies a balance between the serotonergic and dopaminergic systems, but at the same time also a high activity of the cholinergic system, which forms the basis of attention, willingness to learn, the rapid grasp and classification of reward and punishment stimuli, as well as low distractibility and high goal focus (Hasselmo and Sarter 2011).

We see that there is no "one-to-one" relationship whatsoever between basic personality traits, as treated in the Big Five or modified variants, and the six psychoneural systems listed, and certainly not—as originally assumed—between the Big Five personality traits presented and the amount of neurotransmitters, peptides and hormones released. Rather, the psychoneural systems and their active substances are involved in the various traits in a complex but empirically ascertainable manner.

There is a complex positive (*agonistic*) and/or negative (*antagonistic*) correlation of effects between the six basic systems mentioned (details in Roth and Strüber 2018). Thus, the stress processing system and the self-soothing system must work closely together to achieve a level of activation appropriate to the problem on the one hand and to bring the organism back to calm after the stress has ended on the other. Severe stress, on the other hand, suppresses the serotonergic system in its calming function. A strong link exists between the self-soothing system and the attachment system in that the release of oxytocin causes an increase in serotonin levels as well as a release of brain-derived opioids. Oxytocin, like serotonin, can also reduce stress levels.

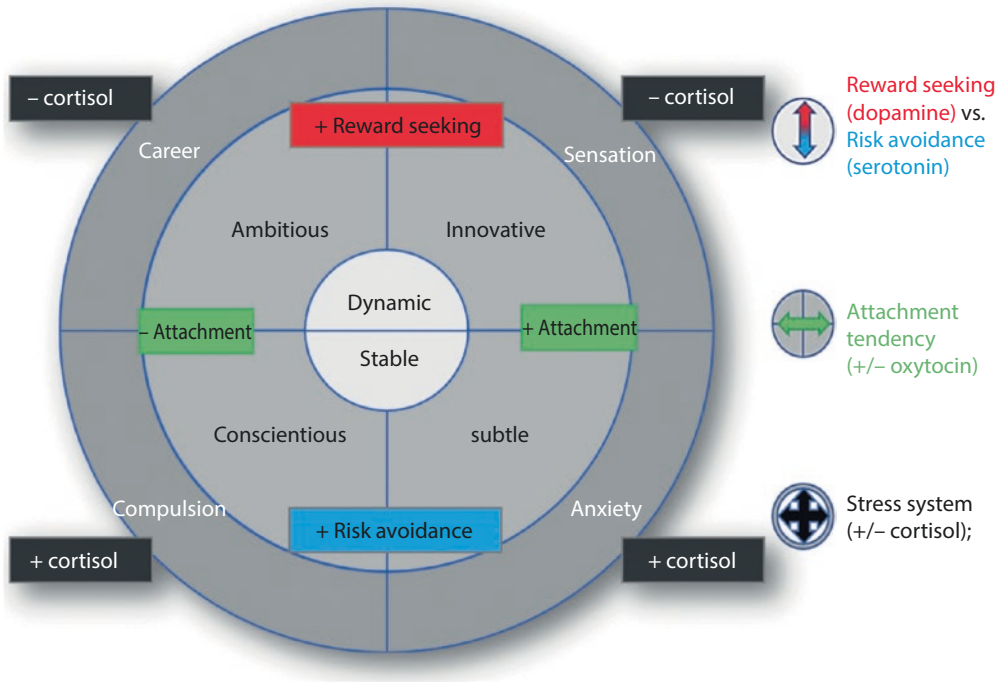
Impulse control and sense of reality/perception of risk are negatively coupled. A low level of impulse control can override the sense of reality and risk perception; a high level of sense of reality and risk perception contributes significantly to impulse control. Finally, the motivational system can connect with the other basic systems in almost any way, evaluating their respective states as pleasurable or desirable or as painful and to be avoided, depending on the personality. One person loves excitement

and the thrill, another the quiet; one person is happy only in company, another wants to be by himself, etc.

The four levels and six basic psychoneural systems determine temperament and personality, and thus the psyche of a person, in their respective manifestations, within the framework of the interaction of the factors genes, epigenetic factors, prenatal and postnatal influences and experiences.

6.3.4.3 A Neuroscientifically Based Personality Typology

How can the personality systems just described be reconciled with the findings of psychological and neuroscientific personality research? In the following, we will show that this can be achieved particularly well if we consider the two basic characteristics of plasticity/dynamics and stability from the newer approaches presented in ▶ Sect. 6.3.2. As shown schematically in ◘ Fig. 6.4, these two traits form the basis for two different personality types, whereby we want to assign a particularly change-ready *dynamic* personality to the trait plasticity and a *stable* personality to the trait stability. The main reason for this dichotomy is probably the different dominance of the dopaminergic reward expectancy system on the one hand and the risk avoidance and impulse inhibition systems on the other. The two basic types that can be described in this way can in turn be subdivided into two subtypes—possibly on the basis of a characteristic activity of the oxytocin-attachment system in each case. Under certain conditions, and especially when individual genetic predisposition and/or significant early or even later stressful experiences produce an over- or underfunctioning of the stress system, the four subtypes may each develop a characteristic



◘ **Fig. 6.4** Personality and neuromodulators, Details in text

psychopathology. Some of this is still somewhat speculative, but quite compatible with current findings.

The first of the two basic types, the *Dynamic*, shows a high degree of enterprise, daring, openness to other people and a greater willingness to change. The opposite type of the Dynamic is the *Stable*. He loves order, ensures that private matters and professional business run smoothly, carefully weighs opportunities and risks, leaves opportunities unused if they are associated with higher uncertainty, values sincerity, punctuality and reliability.

Underlying these two basic personality types, "Dynamic" and "Stable", appears to be a characteristic expression of reward sensitivity, risk assessment and impulse inhibition in each case. The dynamic person shows a high reward orientation, combined with a lower risk avoidance and impulse inhibition. In the Stable, on the other hand, reward orientation takes a back seat in favor of pronounced risk avoidance and high impulse inhibition. In the case of the Dynamic, two subtypes can be distinguished, the *ambitious* and the *innovative*, each of which forms the basis for a characteristic psychopathology. The individual development of the attachment system then determines which of the two subtypes is formed—although there is still a lot of research to be done here. The ambitious person has a strong will to succeed. He sees himself as strong and independent and attaches great importance to material possessions and recognition. These traits are also characteristic of individuals with an insecure-distant inner model of attachment, that is, individuals who have dialed down their own emotional and attachment needs. Under certain conditions, such as when there is an under-functioning of the stress system following early childhood traumatic experiences or later stress, the Ambitious subtype may develop into the *Careerist*. This person is strongly reward-oriented, likes to announce big goals and shows a high ruthlessness in achieving his goals. He often takes high risks and has clear empathy deficits. At the same time, these individuals experience a constant inner restlessness and "emptiness", which is only briefly eliminated by experiences of success and happiness, which provide the "kick". This type is found in people with antisocial personality disorder ("psychopathy") or malignant narcissism.

The other subtype of the dynamic, the *innovative*, can be enthusiastic about creative innovations. He usually enjoys being with people and is open to change. In this case, the attachment system is probably more active than in the ambitious person—after all, one of the properties of the oxytocin that is central to this system is to promote creativity and openness. The innovative person can also develop problematic characteristics under certain conditions, such as a strong sense of success. Thus the innovative *person* can become a *sensation* seeker. This person loves change for change's sake, likes the excitement that comes with change, always has new plans before he has finished previous projects, shows an increased carelessness and unreliability. He is willing to sacrifice goal-oriented action for the sake of the "thrill" that comes with change. As with the ambitious dynamic, a characteristic under-functioning of the stress system is likely to be involved in this elevation of extraverted, creative, and change-ready behavior into the pathological.

In the *Stable*, whose characteristic trait is risk avoidance, it is apparently the individual level of activity of the attachment system that determines whether he is more conscientious or sensitive. The *conscientious person* is driven by a desire for order and correct procedures, and his motives and goals are often antithetical to those of the innovative dynamist; he appears to have a lowered need for social relationships. The *conscientious person* can develop into an *obsessive-dogmatic person*. This person is exclusively concerned with correctness ("continuing to act as before"), rigidly

adheres to his views and the usual procedures, even if this brings disadvantages, and insists on principles. Increasing these tendencies, he shows a clear aversion to change and a deeply rooted conservatism; new things are fundamentally rejected because they are perceived as threatening. This type is prone to obsessive-compulsive disorders. It can be assumed that genetic predispositions, early experiences of stress and/or the experience of later chronic stress have led to an over-functioning of the stress system.

This is different with the *sensitive person*, who reacts socially and empathically despite his pronounced risk avoidance. In contrast to the conscientious stable person, the attachment system is obviously very active. In its negative manifestation, the sensitive person can easily become the *fearfully insecure person* who immediately thinks of everything that could happen in his environment and also to him. He is easily thrown off balance. He perceives the world more negatively than the average, and is therefore often worried, ashamed, insecure, embarrassed, nervous or sad. In him, as in the Conscientious Stable, genetic predisposition and/or prenatal, early childhood, or later chronic stress experiences are likely to have caused his stress system to tend to be overactive and his ability to self-soothe to be deficient. He overreacts to high demands and has difficulty ending his internal state of alarm—he cannot calm down and continues to ruminate on his difficulties for a long time following the high demands. A deficiency of endogenous opioids may also diminish his ability to feel pleasure and joy. Psychopathologically, he may develop towards anxiety disorders or depression.

So we see that from the four "normal types" of personality, namely in the area of the dynamic the ambitious and the innovative and in the area of the stable the sensitive and the conscientious, four "deviant types" can be derived relatively easily, namely the careerist, the change addict, the obsessive-dogmatic and the anxious-insecure. In these deviant types, a transition to full-blown mental disorders is possible in the form of antisocial personality disorder, sensation-seeking, obsessive-compulsive disorder, depression, and anxiety.

6.4 Summary: Brain and Personality

Contemporary personality psychology assumes that a person's personality is a highly individual combination of characteristics. With regard to the development of personality and aptitude tests, it attempts to reduce the large number of such characteristics to a few and more or less selective basic characteristics or basic factors, which then in turn have certain sub-factors. The basic factors include the "Big Five", namely extraversion, neuroticism, agreeableness, conscientiousness and openness/intellect. However, it is disputed whether these basic factors are actually all separable—some authors propose a grouping of the Big Five into *stability* (neuroticism, agreeableness, conscientiousness) and *plasticity* (extraversion, openness). Other authors assume a basic polarity between *extraversion-approach* and *neuroticism-avoidance*. Finally, there are a number of personality traits such as *impulsivity*, *attachment ability*, *flexibility*, and *stress tolerance* that experts believe are "at cross-purposes" with the Big Five.

A neurobiological foundation of the most important personality traits is achieved if we start from four levels of personality and the six basic psychoneural systems located on them. We then understand more precisely how the stress processing system, the self-soothing system or the system of emotional control, the reward and reward expectation system, the attachment system, the impulse control system and the reality perception system build on each other and interact positively and negatively with each other. The stress processing system and the emotional control and self-soothing system

play the most important role here, as they develop first and influence the formation of the other systems. Favorable development of these two systems, some of which occurs before birth, is the most important prerequisite for the development of a balanced, introspective personality with moderate to high scores on the traits extraversion, agreeableness, conscience, and openness and low scores on the trait neuroticism. It also forms a robust resistance, **resilience**, to subsequent negative developments.

Resilience

In the context of personality development, **resilience** refers to resistance to psychological stress such as stress, abuse, etc., whereas vulnerability refers to susceptibility to such negative experiences.

If, on the other hand, prenatal disorders occur in the formation of these systems, this can lead to a **vulnerability** to the effects of negative experiences. This is accompanied by low values in the traits extraversion, agreeableness and openness, often high values in the trait conscientiousness and equally high values in the trait neuroticism. An anxious, insecure, withdrawn and sensitive personality develops.

Summary

In this chapter we have dealt with the development and structure of the personality, the effect of emotions and the emergence of motives and goals from a psychological point of view. This is about the answer to the question, which is still central today, why people are the way they are and why they do what they do. No single science can provide a satisfactory answer, not even psychology or neurobiology. It is important to identify precisely the manifestations of personality, emotion and motivation from a psychological point of view, but such findings "hang in the air" if one does not ask about their neurobiological foundations.

Everything we perceive, feel, think and do is closely related to brain processes, which in turn are conditioned by genetic and epigenetic factors as well as prenatal and postnatal influences. Recognizing these connections enables us to better understand phenomena of human action, for example the fact that rational arguments and mere insight often have no effect on our behavior, that strong emotions (affects) can lead us to act completely "irrationally". Or why a good resolution is often not put into practice. Psychological explanations, which always have counterarguments, can only be made plausible in all these cases by the findings of brain research. This is a great step forward. However, no serious brain researcher will deduce from this that brain research can ever replace psychology, because it cannot do without precise knowledge of psychological processes.

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