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Implications of neuroscientific research for psychotherapy

The topics in neuroscience that we psychologists studied in the 1970s under the keyword "physiological psychology" left me with unpleasant impressions of the discipline. You may remember, as I do, pitiful laboratory cats with electrodes in their brains, odd experiments in perception having no apparent connection to psychotherapy and of no interest to future psychotherapists, tedious hours spent memorizing the parts of the brain, and depressing grades on tests on the subject.

Today, however, my impression of neuroscience has changed fundamentally. Exploding advances in the neurosciences of the last ten years are of extreme interest to psychotherapists (DOLAN, 2002; SULZ, 2002). Neuroscientific research has the potential to become the basis for integrating the estranged schools of psychotherapy. The new findings of the neurosciences are shedding light on the practice of psychotherapy and providing a natural scientific basis for some central psychological concepts. In the following, we provide an overview of central, new linkages between the neurosciences and psychotherapeutic practice. We examine connections between:

- Mental/emotional processes and memory contents
- Mental/emotional development and learning
- Self-regulation and unconscious processes

The neurosciences view the brain as a self-organizing storehouse of experience. The older idea that there is an upper-level control center in the brain is no longer held to be valid. The human brain is a survival organ that is particularly specialized to respond flexibly to changing environments. It allows the initiation and maintenance of postnatal life as an interactional process, that is, it allows continuous perception, evaluation, and response to the information entering the system without pause (KOUKKOU & LEHMANN, 1998a, p. 328). This ability is founded in the fact that on the basis of the experiences the organism has through life, the brain can change its own structures. This means that the brain organizes itself and its behavior on the basis of its own biography (FUSTER, 1995).

The brain's task is to take charge of the "psychobiological well being," as KOUKKOU and LEHMANN call it, of the organism in which it resides. The authors find it reasonable to assume fundamentally that the human brain has the potential to possess psychobiological health (1988a, p. 381). For salutogenetic-oriented psychotherapy, this is a fascinating point of view. If every human brain has the fundamental potential for health, then we have a neuroscientific argument for psychotherapeutic methods that emphasize the activation of resources. GRAWE (2002) holds resource activation to be one of the essential effective factors in successful psychotherapy. Resource-oriented psychotherapy would then consist in the optimal promotion of the health potential of the brains of patients and clients. To obtain a more precise idea of what neuroscience-based resource activation would look like, it is necessary to examine more closely how the mind, or "psyche," can be represented in the models of the brain's information processing.

"The mind" in a neuroscientific view

The brain fulfills its task of assuring psychobiological well-being by means of storing everything that the organism to which it belongs experiences through life. Based on this stored knowledge, behaviors that are found to be adequate are selected and executed. In computer language, we could say that the brain is in a permanent process of updating. Unlike much software, however, this updating does not occur just once a year as new versions of a program come on the market, but instead occurs without interruption until the end of life, when the brain turns off its activity. The brain is an organ that is continually built and rebuilt by one's experiences.

The things an organism does are based on the knowledge that its brain has stored. A part of this knowledge is inherited; another part is learned. To make this knowledge available for implementation in order to guide and control behavior, it must be stored in a retrievable way. This storage of knowledge in a retrievable form is the achievement of memory. In day-to-day language, we usually think of "memory" as the storage of only very specific information, such as when we remember telephone numbers, recipes, or French vocabulary. Memory research provides a more extensive concept of memory:

> Indeed, we would be nothing without memory and recollection; we would not know who and where we are, what day it is, and in what month and year we find ourselves, who the people are around us, why we are in a particular place and not somewhere else, what others expect of us, what the meaning of things and events around us is. We would be fearful of many things without reason, but we would also overlook many dangers. We would not be able to understand or speak a single sentence, not a single gesture or facial expression. Even slightly more complex movements would prove to be difficult, because most movements are practiced and thus depend upon learning and memory. In a nutshell, we would all be lost (ROTH, 2001, p. 150, freely translated).

When in the following we speak of stored knowledge and memory, we always refer to this very broad concept of memory. This is acceptable from the perspective of the neurosciences, because at the level of the nerve cell, comparable processes take place no matter whether a human being is learning the Ten Commandments at church, training to perform a triple Rittberger on the ice, or collecting erotic experiences during clandestine encounters.

As memory processes provide the basis for the brain's fulfillment of the task of assuring survival, health, and well-being, from the neuroscientific perspective it follows quite logically that the knowledge collected in memory is the very basis of mental functioning. The interaction of the growing individual with its own external and internal realities produces its own knowledge (memory, personal biography) or – in the language of psychoanalysis – mental apparatus (Koukkou & Lehmann, 1996). This perspective, which views mental processes from the memory theory standpoint, has far-reaching consequences for psychotherapy. For one thing, it leads to a consistently constructivist position (Johnson, 2003). For another, it can help us to avoid unnecessary labeling processes in psychodiagnosis.

The constructivist basic position results from a documented neuroscientific fact that Roth (1996) describes as follows: The reality in which we live is a construct of the brain (p. 21). From the perspective of neuroscience there is no unambiguous connection between environmental stimuli and internal processes within the brain. It is important to distinguish strictly between *signals*, such as the arousal states produced by the sensory organs, and their *meanings*. Meaning is *assigned* to the activation of the neurons only by the cognitive processing systems, in dependency upon the context in which the excited states occur (Roth, 1996, p. 108).

The constructivist principle also holds for memory: What enters into storage in the brain are not Polaroid snapshots of people, objects, and landscapes or taped recordings of music or speech. There are no crib sheets like the teleprompter texts that help politicians to earn their daily bread. In other words, there does not appear to be storage of any form of concrete copies – no "miniaturized" copies, copies "on microfilm," or "hard copies." Considering the enormous amount of knowledge that we acquire throughout life, facsimile storage would overwhelm the storage capacity of the system. If the brain were like a traditional library, our "shelves" would soon be just as full as the shelves in the library usually are. Moreover, facsimile storage would result in serious retrieval problems. As each one of us can verify directly, when we call to mind a certain object, face, or event, what we retrieve is not an exact reproduction, but rather an interpretation, a reconstruction of the original (Damasio, 1994, p. 145).

Because memory processes form the basis of mental/emotional activity, the constructivist principle also holds for the mind: Those aspects of human existence that we call the mind, self, soul are "creations" of the dynamic, adaptive, and synthetic workings of billions of neurons of the human brain (Koukkou & Lehman, 1996). From the neuroscientific perspective, the content of the mental apparatus is individually constructed knowledge. Part of this knowledge is inherited; another part is acquired as we mature and develop. The learning processes in the early years are critical. Like all brains capable of learning, the human brain is also the most deeply and most sustainably programmable during the phase of brain development (Hüther et al., 1999). The brain of a small organism that, for instance, experiences a lot of fear and stress in childhood stores from the start its experiences in dealing with these states and utilizes these experiences from then on in order to safeguard well-being to the extent possible. The earlier that these crucial experiences in dealing with fear can be engraved in the brain, that is, the more plastic the brain connections at the time the experiences are registered, the more strongly that they are stored in the brain for the rest of life. They then look like innate instincts and can be triggered like innate instincts, but they are not innate instincts. They are the stored experiences of early childhood of coping with fear and stress (Hüther, 2001, p. 51). Of course, the lasting experiences stored in the brain can also be positive experiences, which presents an interesting parallel to the psychoanalytic concept of "basic trust."

Stemming from this neuroscientific view of the mental apparatus as knowledge storage of experiences, there results a precise conception of what constitutes mental/emotional health. If the mental apparatus consists of the knowledge that the individual utilizes to guide behavior in order to assure well-being, then neurotic behavior bases ultimately upon a knowledge structure that provides the brain with sub-optimal support for the task. Koukkou and Lehmann see this neuroscientific conception as an alternative to the psychoanalytic conflict model, stating that the pathogenesis of neurosis cannot be explained as conflicts between the "instincts" and socialization. Instead the explanation of neurosis lies in the quality of the knowledge that the individual acquires and creates from interactions with the social realities that are important at different ages. In other words, neurosis can be explained through the general adaptability of brain mechanisms (1998a, p. 287, see also LeDoux, 2002).

The neuroscientific perspective is of great interest for psychotherapy, because it offers a very pragmatic explanation of neurosis. In this view, there is no longer a need to seek mysterious inner parts of the mental apparatus, whose existence and composition/nature are known only to experts and which are a point of controversy among the various schools of psychotherapy. If a person behaves in a way that is not conducive to his or her psychobiological well being, then he or she simply has inadequate knowledge of ways to produce the desired state. Psychological disorders are the "products" (thoughts and/or emotions and/or actions and/or fantasies, dreams, decisions, function states of various organs) of knowledge and context-determined information processing by the brain that is based on maladaptive knowledge (ibid., p.176). Tress (2002) has developed a practical method of assessing the emergence of maladaptive patterns in interactional contexts.

In the framework of neuroscientifically oriented psychotherapeutic theory development, the concept of maladaptive knowledge refers to experiences that are not useful for the assuring of psychobiological well-being. In this approach, there is no "sick" or "healthy"; there is only "useless" (maladaptive) and "useful" (adaptive) knowledge. Following these concepts, the usability of experiences that an individual has is assessed *exclusively* in terms of whether the knowledge contributes to maintaining the individual's well-being or not. In addition to the potential of this perspective to contribute towards an integrative theory of psychotherapy, it can also free patients from the stigma that is associated with mental illness. It is indeed so that this stigma, reinforced by the language of illness still in current use in clinical psychology, places an additional burden on patients who are already suffering from their symptoms.

The psychotherapist thus has a significant function to fulfill: the function of teacher, a teacher who helps the client to acquire beneficial adaptive knowledge. How it is that this learning process can occur, however, requires an understanding of the learning processes at the level of the nerve cells.

Learning at the neuronal level

Once the central importance of memory processes for mental functioning has been established, the question arises as to how the neurons build and structure memory. How is information stored, and – of particular interest to psychotherapy – how is additional, new information acquired? HEBB'S postulate of synaptic plasticity (1949) is today the most plausible, well-documented neuroscientific model of learning. Hebb's concept is simple and elegant. Plasticity arises when two or more neurons fire at the same time, following the standard rule that "cells that fire together, wire together," the notion that cells that are often active simultaneously tend to become associated through neural connections they share, such that activity in the one will facilitate activity in the other. Hebb developed the concept of plastic synapses that increase their readiness to transmit the more often that they are used. A synapse is a gap between two neurons that functions as the site of information transfer, through chemical transmitters, from one neuron to another (see Figure 1). Simultaneous firing strengthens the synaptic connection between neurons and thus improves information transfer. In today's rephrasing of Hebb's famous postulate, we can say that modifications in the synaptic transmission efficacy are driven by correlations in the firing activity of pre- and post-synaptic neurons (GERSTNER & KISTLER, 2002). This correlation-based learning is now generally called *Hebbian learning*. We can think of brain processes as similar to processes in the musculature that occur as the result of strength training at the gym. Those sought-after "washboard" abdominals are built according to a similar principle: if muscles are used frequently, their performance increases, while seldom-used muscles decrease in strength. In the case of neurons, increased or decreased efficacy is expressed as the ability to fire.

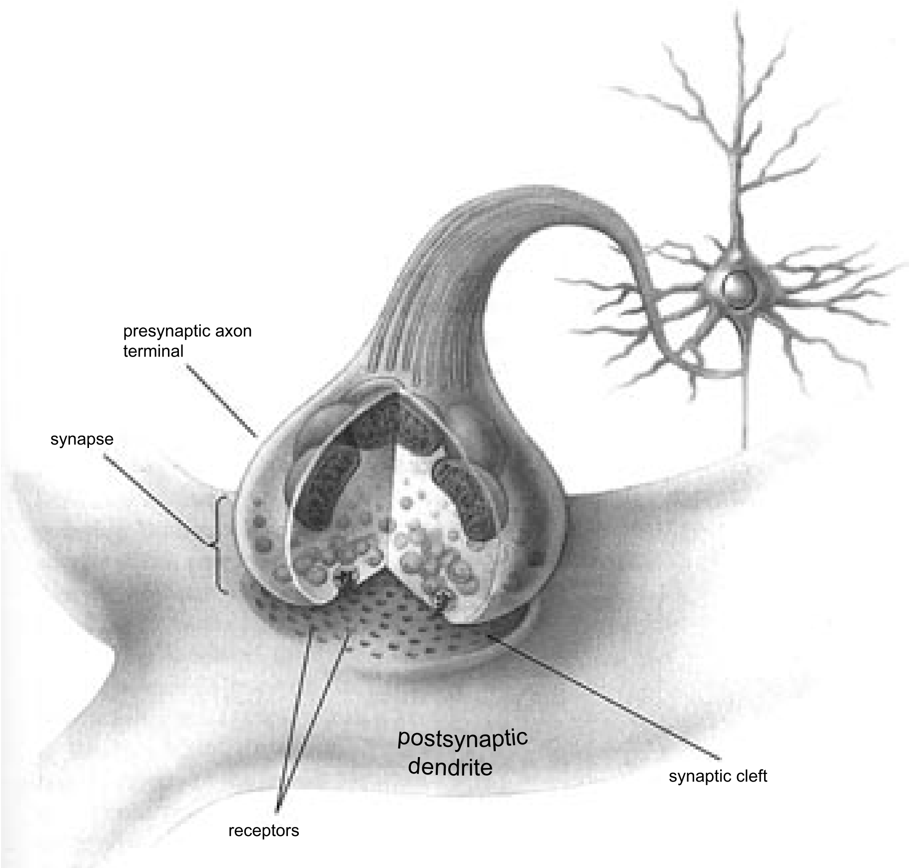
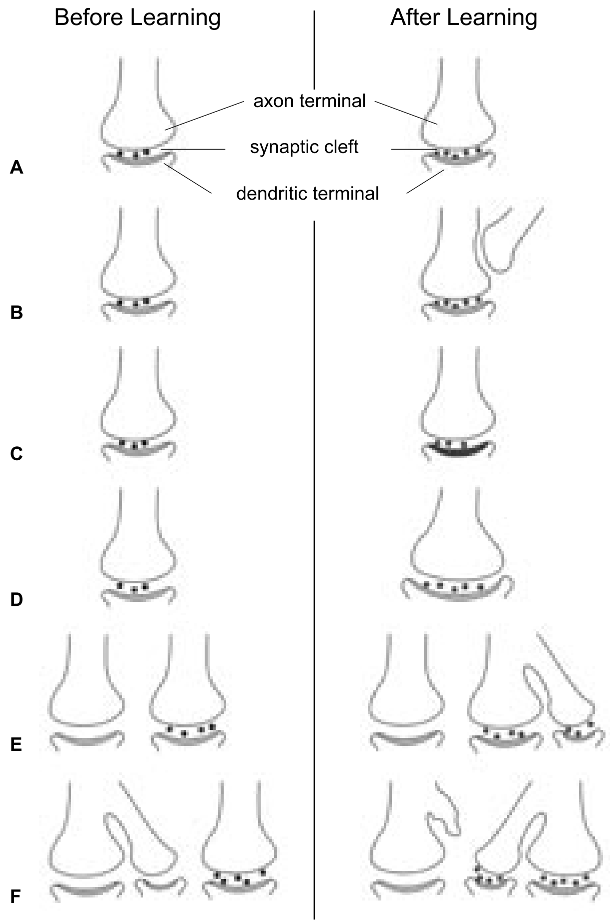


Figure 1: Synapse with presynaptic axon terminal and postsynaptic dendrite (adapted from Bear, Connors & Paradiso, 1996)

Increased synaptic transmission efficacy through frequent use of specific neuronal activity patterns is called *facilitation* in the neurosciences. HÜTHER (1997) describes the process of facilitation in terms of a path that is forged through difficult terrain. The more often that the pathway is traversed, the wider it becomes. After several years of frequent use, the pathway becomes a broad, easily traveled road. Paths that are seldom or no longer used disappear as they are covered by wild growth. Following Hüther's metaphor, well-facilitated connections between individual neurons in the brain are well-built, broad roads. Connections between neurons that are not utilized disappear from the landscape of the brain, as their probability of action potentials and their synaptic transmission efficacy decline. Herein lies the answer to the question of the neuronal basis of memory.

At the neruoscientific level, learning takes place through Hebbian plastic adaptations, or Hebbian learning. Learning is the strengthening of synaptic connections between neurons (LeDoux, 1996, p. 229). All processes of people's learning base upon this mechanism, from memorizing French vocabulary to learning to bake a cake or dance the tango. Rosenzweig and Bennett (1995) provide an excellent overview of the topic of plasticity; a good introduction to the molecular bases of learning is provided by Kandel und Hawkins (1994); and a paper by Toni et al. (1999) contains impressive pictures of the formation of new synapses. Videos of these growth processes are available for viewing on the Internet (www.fmi.ch/members/andrew.matus/video.htm). There exist also hints, that reactivation of a consolidated memory can return it to a labile, sensitive state in which it can be modified (Nader, 2003).



A: Following a training procedure, each new impulse in the affected neuronal system leads to increased release of neurotransmitter molecules (shown as dots).
B: An interneuron modulates the polarization of the axon terminal and triggers the release of neurotransmitter molecules per nerve impulse.
C: Modifications of the postsynaptic receptor membrane results in stronger reaction to same amount of neurotransmitter substance.
D: The area of synaptic contact increases with training.
E: An excitation pattern that is used frequently increases the number of synaptic contacts.
F: A frequently used neural connection "takes over" less used synapses (adapted from Birbaumer & Schmidt, 1996)

Figure 2: Synaptic modifications that may be the underlying basis for storage.

Figure 2 shows some current conceptions of the ways in which neurons change when learning occurs. Remember: learning, in the neuroscientific sense, is the frequent joint use of neurons. The left side of the figure shows the state of the synapses prior to learning; at the right the figure shows the possible changes that learning triggers. Example A shows increased transmission efficacy of the neuronal connection due to the increased release of chemical messages, the neurotransmitters. Examples B and E show that even new synaptic connections can be formed. Example C shows a synapse where, after frequent use, the amount of transmitter substances released remains the same, but due to the increased sensitivity at the surface of the post-synaptic receptor, the synapse reacts more rapidly to the same chemical signals. D is a nice example of what we compared to strength training of the muscles above. Following learning, the synapse is like the biceps that has become full and thick through exercise. Example F is of special interest to psychologists: in human learning it is often important to learn something new *and* at the same time unlearn older patterns. A client who wants to learn to stay more relaxed in stressful situations rather than immediately fly off the handle has to unlearn the old behavior as well as acquire new ways of responding. This can be achieved if the old neural network is utilized as little as possible. Example F shows what happens to a neuronal connection that is no longer used: it is lost and replaced by new connections among neurons. In psychology we would call this a successful developmental step.

Memory is based on neural networks

In seeking to understand Hebbian synaptic plasticity, we have thus far only looked at the case of two neurons. However, plastic changes in the brain not only create connections between pairs of neurons, but also within entire groups of neurons. Memory is not stored in any single brain center; it is built up in many components in far-reaching neural networks (GOLDMAN-RAKIC, 1992), and memory processes take place in widely distributed, multi-segmented networks (MARKOWITSCH, 1998, p. 104). The brain contains between one billion and three trillion neurons (THE SOCIETY FOR NEUROSCIENCE, 2002, p. 4). Individual nerve cells are connected to one another through synapses and dendrites, as shown in Figure 3. At the level of the neurons, the knowledge that makes up the contents of memory can be seen as enhanced probability of the activation of specific patterns of neuronal excitation. These patterns of excitation are organized in so-called neural networks, or cell assemblies. Cell assemblies are the building blocks of memory. Without them, we would drown in a sea of sensory data. We would not be capable of organizing or retrieving the enormous streams of information that we receive.

Cell assemblies consist of many thousands of cells, but the connections develop in such a way that activating any part of the loop by a stimulus causes the rest of it to activate, too. Repetition leads to a strengthening of the connections of the entire nerve complex as a strong loop and increases the possibility of the whole thing being activated in the future. EDELMAN (1987)

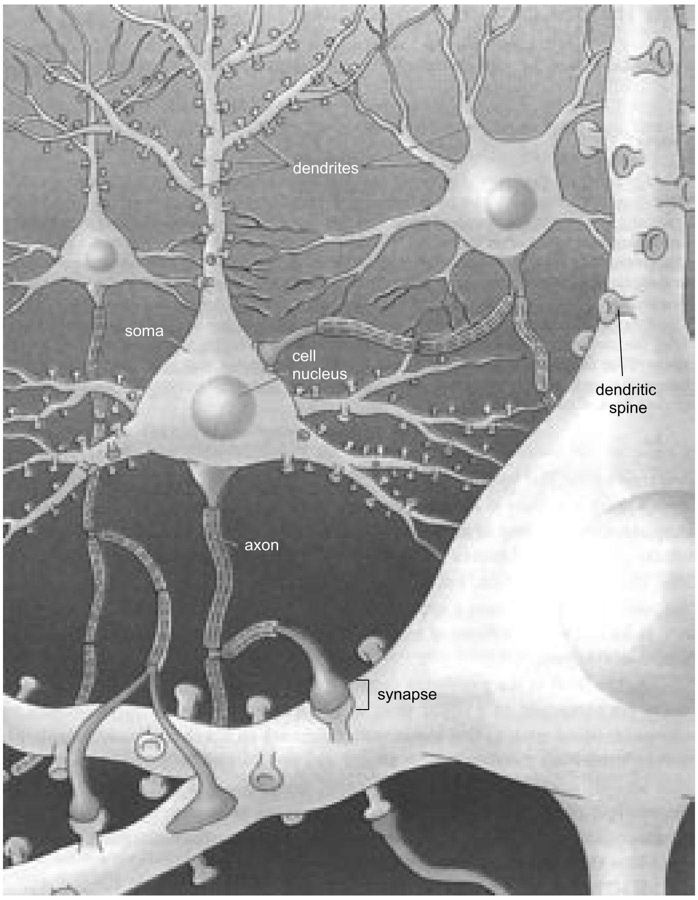


Figure 3: Neural netwirks (taken from Rosenzweig, Leiman & Breedlove, 1996)

described this phenomenon using his concept of reentrant mapping. As an example of the process of reentrant mapping RATEY (2001) described the emergence of a neural network called "grandmother" this way: According to Edelman's theory, the perception of a chair or your own grandmother is based upon repeatedly occurring signals that link the activity of several maps in regions of the brain … each brain region contributes to your recognition of the chair or grandmother, and that explains why recognition is triggered by a number of different kinds of sensory information: the smell of mothballs, the taste of paprika, a gray-haired woman, a figure sitting and crocheting in a rocking chair, an elderly female voice (RATEY, 2001, p. 173). In the language of neuroscience, in a neural network the information from the different areas of the brain become connected as units through *multidimensional encoding*. KOUKKOU and

LEHMANN (1998a) write that the mnemonic representations (the neural networks) are encoded in individually acquired symbols of language; in other, non-verbal representations such as forms and colors and so on; and in individually acquired emotional information (p. 352).

There are other interesting points of view concerning multidimensional encoding, however. In their definitions of multidimensional encoding, RATEY as well as KOUKKOU & LEHMANN refer to the encoding of sensory signals, linguistic-cognitive aspects, and emotional aspects. DAMASIO (1999) adds still another aspect that contributes to the multidimensional encoding of a neural network: memories of an object that was once perceived in reality contain not only representations of sensory aspects like color, shape, or sound, but also representations of (bodily) adaptive responses, body state maps, that necessarily accompany the collecting of the sensory signals. Further, memories also contain representations of the unavoidable emotional responses to the object. When we recollect an object, we thus retrieve not only sensory data, but also the accompanying motor and emotional data. This means that we retrieve not only the sensory peculiarities of the real object, but also our past responses to that object (1999, p. 160). Neural networks therefore also encode information at the level of the body. Taking Ratey's example of "grandmother," this would mean that when we remember Grandma at the emotional level, we might get a feeling of security, for example, and remembering her at the physical level, we might experience a good "gut feeling."

Hebbian plasticity also applies to groups of neurons. When particular excitation patterns become well established through frequent repetition and, therefore, linked in cell assemblies, the group of neurons becomes more easily activated. The interesting fact for psychology here lies in one of the brain's particular characteristics, the ability to see perceived incomplete patterns as closed and complete, which was already described by Gestalt psychology as the law of closure (TSCHACHER, 1997) and is related to invariant pattern recognition. With increasing facilitation of the neural network, the pattern of excitation is increasingly easy to activate from very different points and with ever less sensory information. This explains why hearing the song that was playing during our first kiss can immediately evoke all the pleasurable feelings that belonged to that context. This effect can be unpleasant as well, such as when the typical "hospital smell" triggers all kinds of unpleasant associations. ROTH (1996) writes that sometimes, mere fragments of real sensory data are sufficient to generate a complete percept, which originates not from the sensory organs, but comes instead from memory (p. 267). GRAWE (2002) describes this as follows: Individual memory contents are represented by specific neuronal activity patterns for which, due to previous facilitation, there is an increased readiness in the form of synaptic connection weights, as Hebb described for cell assemblies. Recalling a memory involves reconstituting the neuronal activity pattern present at previous input under the influence of current context conditions (p. 230).

Neural networks build and organize psychological events

Up to now, we have examined how learning takes place and how, at the level of the neuron, the building blocks of memory become linked. The task now is to establish the connection to psychology. From the perspective of neuroscience, all aspects of normal mental functioning as well as all neurotic behavior arise from the normal functioning of the mnemonic functions of the human brain (KOUKKOU & LEHMANN, 1996). Furthermore, the organizer of the genesis, coordination, and control of the quality of all dimensions of human behavior, at all ages and in all states of consciousness, is the amount and quality of the acquired and created knowledge in the brain of the individual. Here memory and the stored information take on crucial significance as regards both the human mind and behavioral control.

Psychologists have a term for the phenomenon of connectivity, the joint activity of many components in a unit, which in the terminology of neuroscience is called the neural network. The psychological term is *schema*. GRAWE (2002) writes that Hebb's cell assemblies, Edelman's neuronal groups, or facilitated neuronal activity patterns are what PIAGET (1976), BARTLETT (1932), or NEISSER (1967) called "schemata."

The way that a schema influences perception can be described as follows. The percept is actively "constructed" on the basis of the available activity pattern stored as memory content, whereby current, real context conditions together with the facilitated activation tendencies influence the perception that actually arises (GRAWE, 2002). To illustrate this concept, we can apply the notion of schemata-guided perception to Ratey's "grandmother." Ratey's grandmother evidently carried the scent of mothballs and liked to cook a dish seasoned with paprika that left a strong impression on the young boy (Ratey does not mention whether this was a pleasant or unpleasant emotion). She sat in a rocking chair crocheting and had the voice of an old woman. At the cognitive level, she is encoded semantically as "grandmother," and, in addition, at the emotional level a number of feelings connected with grandmother have been stored in Ratey's memory (such as a feeling of comfort) as well as various encoded bodily states (a good "gut feeling"). Because Ratey saw his grandmother often when he was a boy, all the different sensory data, which are perceived in various regions of the brain, have become associated in a neural "grandmother" network through reentrant mapping. In the language of psychology, we would speak of a grandmother *schema* that is encoded in multiple dimensions – cognitive, emotional, bodily.

In the framework of a similar concept in perceptual theory, KOUKKOU and LEHMANN (1998a) find a neurological basis for the psychoanalytical concept of transference (p. 362f). As we have noted, the brain has the ability to see figures with gaps as closed and complete (law of closure). Just one element of the neural network, if well established, can suffice to co-activate the entire network. If Mr. Ratey comes for an analytic session, and his analyst possesses two or three elements that activate his "grandmother" neural network (say, gray hair or elderly voice), the "grandmother" glasses he wears will color his perception of the analyst. Or, in the language of psychoanalysis, "grandmother" transference occurs.

Beyond a person's features and characteristics, however, we also learn the experiences that we have when we interact with that person. As MERTENS (1998, p. 72) describes it, as development progresses, children come to form expectations of how the significant other will react to their own intentions and actions, and they also think about the motives and intentions that guide the other's behavior. During the learning process, a neural network develops for "grandmother" that, in addition to schema-guided perception, also activates corresponding action tendencies, emotional tendencies, and motivational tendencies. The same applies, of course, for learning processes in relation to animals, objects, or complete sets of contexts and situations.

MERTENS (1998) provides a detailed overview of various psychological concepts that can be readily correlated with neural network models of memory formation. They include PIAGET'S (1952) sensorimotor schemata in the genetic epistemological perspective, DOWNING'S (1997/1994) affect-motor schemata in the body therapy approach, DORNE'S (1993) perceptual-emotional action patterns described from a psychoanalytical perspective, and STERN'S (1985) RIGs (representations of interaction that have been generalized) in early childhood development research.

Staying with this neuroscience-based model of mind, we can describe psychological development as the expansion of memory contents and, therefore, as learning. Following this logic, GRAWE (2002) proposes that psychotherapy can be viewed as the process of modifying memory contents. Psychotherapy, says, Grawe, focuses to a large extent on lasting change to arbitrary, controllable behavior. For this reason, we need models in psychotherapy that do justice to this complex learning process (ibid., p. 276). For Grawe, the goal of psychotherapy is to influence arbitrary, controllable behavior. This raises the question of how mental events are regulated according to the neuroscientific perspective.

How is mental activity regulated?

We have looked at the ways that neuroscience can model mental processing, but now the question arises as to the nature of the regulatory processes that assure the psychobiological well-being of the organism. First of all, it becomes immediately clear that we must discard the notion that the thing that we experience as the self is the central control organ of our lives and mental/emotional lives. Following Grawe, the self that we experience is a quality that emerges from the totality of the neuronal processes that take place within us. Our self does not monitor and control these processes; it is the *product* of those processes (GRAWE, 2002; see also LEDOUX, 2002).

Consciousness, which psychological theories couple with the notion of ego activity, does not take on the central role in the neurosciences that academic psychology has longed ascribed to it. The reason is that the major portion of brain activity takes place via unconscious processes. According to ROTH (2001, p. 218f), only those processes are conscious that are connected with activity of the associative cerebral cortex. This means that we are not conscious of all the activities that occur in the brain when, and for as long as, the associative cortex is not active. Figure 4 shows the areas of the cortex of whose activity we can be conscious.

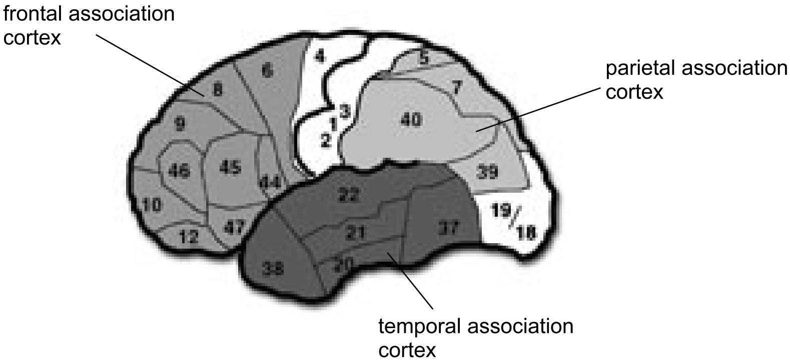


Figure 4: Association cortical areas with conscious activity

The distinction between conscious and unconscious processes in the brain corresponds to the distinction between explicit and implicit processes in the psychology of memory (SCHACTER, 1987). GRAWE (2002) provides a detailed overview. Grawe also writes that the existence of an unconscious function mode is not merely a psychoanalytical notion; it has been demonstrated empirically. The conscious and unconscious modes show different types of functioning and are grounded in different anatomical brain structures. Explicit processes require time and attention; implicit processes can be called up automatically in seconds. Explicit processes are vulnerable to disturbances; implicit processes, once evoked, function reliably. As explicit processes are much more expensive in terms of energy-metabolic physiology than implicit processes, Roth calls them the brain's special tool (ROTH, 2001, p. 231). For the organism, consciousness is a state that it is well-advised to stay clear of, a tool to be used only in emergency situations (ibid., p. 231). Explicit, conscious processes are only set into motion by the brain if processing below the level of consciousness, called preattentive perception in the neurosciences, registers an object or situation that is "new" or "important." If things are registered by preattentive processing as "familiar" or "unimportant", processing remains implicit. The brain has the tendency to transfer even those contents that require focused attention and "expensive" consciousness into implicit memory as soon as possible. This is achieved through repetition and practice.

The more that sequences are repeated, practiced, and then finally made more or less automatic and requiring les effort, the less attention and consciousness is needed. Finally, if at all, only a certain level of accompanying consciousness remains. For instance, if you compare your first driving lesson with how you drive today, the difference between explicit and implicit processing becomes evident. Basically, this ability of the brain to process many things automatically in the implicit mode is an advantage. However, for psychological processes, this ability can sometimes become a problem. This is the case when maladaptive neural networks take over the control function and evoke in people perceptual tendencies, motivational tendencies, and behavioral tendencies that are detrimental to psychobiological well-being.

There is a part of the implicit memory system that is of particular interest to psychotherapy. ROTH calls it emotional experience memory. According to Roth, emotional learning for the most part takes place subcortically and implicitly, even when it is experienced consciously or is induced (2001, p. 320f). For Roth, top-down conscious control over emotional experience memory is hardly possible. This opinion is supported by psychological research. GRAWE (2002) writes that it is not possible to influence emotional reaction tendencies that are stored in implicit emotional memory through conversation alone. ROTH illustrates this with an example: people

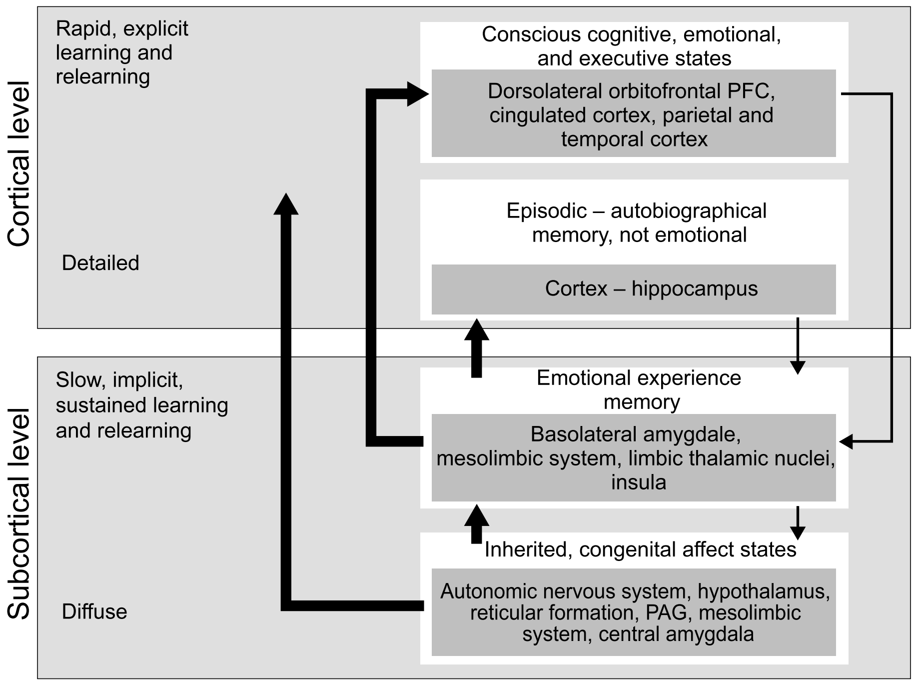


Figure 5: Interaction of cortical and subcortical levels (taken from Roth, 2001)

who are anxious by constitution or due to early childhood conditioning can hardly calm themselves by simply telling themselves that a test is just a test; this recognition will not free people of their examination anxiety (2001, p. 320). Figure 5 shows the interaction of the cortical and subcortical levels according to Roth. Thin and thick arrows represent the degree of influence that the one can have on the other.

Let us look more closely at the example of examination anxiety and how psychotherapy may help. A person's anxiety about tests is stored in the implicit memory system. From the brain's point of view, this is good, because – as Roth notes – our conditioned feelings are nothing more than concentrated life experiences (ROTH, 2001, p. 321). It is advantageous for the organism to make these concentrated life experiences available in this rapidly accessible and highly reliable implicit mode. This useful process becomes a problem only when something is stored in the implicit mode that that does not contribute to the well-being of the organism. In this case, psychotherapy must attempt to replace the unwelcome automatic process with a new process that promotes psychobiological well-being. What does this look like at the neuronal level?

As we have seen, memory contents are stored at the neuronal level in the form of neural networks and corresponding activity patterns. This is true of both explicit and implicit memory. Higher-level psychological processes can also be described in these terms. GRAWE (2002) assumes that all the peculiarities of mental/emotional processes are grounded in particular neuronal excitation patterns. The increased probabilities of these patterns of excitation are stored in various types of memory. Moreover, we know that with strongly established patterns of activity, activation of part of a cell assembly kicks off activation of the entire assembly due to facilitated association. Accordingly, an intended modification of response or behavior would be a new neural network. It would have to be so strongly established that it would replace older, no longer desirable automatic connections. The desired neuronal pattern of excitation must be transferred from the explicit mode to the implicit mode, so that it can run as a process reliably and without disturbance.

This principle can be described quite simply and elegantly, and for that reason the neuroscientific perspective provides in this connection a useful guide for psychology. HÜTHER (2001) writes that the individual must "reorganize the neuronal connections in his brain" (p. 137). Implementation of the principle, acquiring a new neuronal activity pattern and making it automatic, will involve, of course, all manner of effort and difficulties that come with learning in general: time, patience, and perseverance are required. No one can learn to drive a car in a day. GRAWE notes that as long as such new patterns of activity are not yet firmly established, they require conscious processing capacity. Through frequent repetition, the new connections become ever more facilitated. They are more readily activated and gain easier influence over mental activity without requiring consciousness.

Following neuroscientific concepts, psychotherapy can be defined as the acquisition of well-adapted neural activation patterns that, through practice and training, can become automatic enough that they increasingly take over the regulatory function from older, maladaptive activation patterns. This conception of psychotherapy follows quite naturally upon a major finding of psychotherapy research, often emphasized by GRAWE (2002), that successful psychotherapy involves *resource activation*. GRAWE says that the neuroscientific conception of psychotherapy allows us to define that which in the psychotherapeutic process is seen as a resource. This resource can now be defined as a neuronal activity pattern that can be evaluated as positive. Whereas the term "resource" is often used in an unclear manner in psychotherapy contexts (STORCH & KRAUSE, 2002; SCHIEPEK & CREMERS, 2002) and is therefore not always easy to operationalize in practice, resource – conceived as an adaptive neuronal activity pattern – can much better serve as the basis of psychotherapeutic action. In the following section, we turn to the problem of recognizing adaptive neural networks, that is, neural networks that can be called resources.

The diagnostics of adaptive neural networks

Grawe addresses the process of assessment when he defines resource as a neural activation pattern that can be evaluated as positive. How is the psychotherapist to know when neural activation patterns are to be assessed as positive? This issue has a long tradition in psychology and is held to be problematic. Much of the research in this area comes from goal psychology, that branch of psychology that deals with personal goals (an overview is provided in STORCH & KRAUSE, 2002). A well-known finding of this research tradition is that people who follow their goals with a high degree of self-perceived self-determination, self-commitment, or intrinsic motivation (KUHL, 2001, p. 223) report more satisfaction with life and subjective well-being than people whose goals have been determined by others. The problem for psychotherapy lies in correctly identifying the subjective, positive goals of patients. At first glance, it does not seem possible to measure objectively the degree to which an action or goal has been set by the person or by others (KUHL, 2001, p. 223). KANFER ET AL. (1990) quite correctly point out a possible source of error in this process: if we presume to form conclusions about clients' goals and plans merely on the basis of our own ideas, there is always the danger that we will think that we know their plans, when what we are really doing is formulating only our own fantasies of clients' plans (p. 265).

Positive adaptive goals – and thus resources to be activated – would therefore be goals that the patient experiences as highly self-determined and that motivate the patient to achieve realization. The neurosciences offer psychotherapy a useful concept as regards to how these positive adaptive goals can be diagnosed reliably. This is Damasio's hypothesis of "somatic markers" (DAMASIO, 1994), which explains how emotions are biologically indispensable to decision-making. Somatic markers are the bodily sensations ("the gut feelings") that are associated with a particular outcome of an action. Somatic markers are part of a biological assessment system that emerges through experience and functions using physical and/or emotional signals. Somatic markers control appetence (seek pleasure) and avoidance behavior (avoid pain). All objects and situations that an organism experiences leave somatic markers that store an assessment of the encounter. Evaluation consists in a dual system of "was good, seek out again" or "was bad, avoid in future" and takes place extremely rapid (<120ms) (SMITH ET AL., 2003). If a person encounters a similar object or situation later on, or even anticipates how she will respond to such an encounter when planning and thinking about future outcomes, somatic markers provide her with instantaneous information on her previous experience (BECHARA ET AL., 1997). Of course, decision-making also involves reasoning, but it comes into play only after somatic markers have long been activated. DAMASIO (1994) describes how the system of somatic markers works:

> In a "situation which calls for choice ... the brain of a normal, intelligent, and educated adult reacts to the situation by rapidly creating scenarios of possible response options *and* related outcomes. To our consciousness, the scenarios are made of multiple imaginary scenes, not really a smooth film, but rather pictorial flashes of key images in those scenes, jump cut from one frame to another, in quick juxtapositions" (p. 170). ... "The key components unfold in our minds instantly, sketchily, and virtually simultaneously, too fast for the details to be clearly defined. But now, imagine that *before* you apply any kind of cost/benefit analysis to the premises, and before you reason toward the solution of the problem, something quite important happens: When the bad outcome connected with a given response option comes into mind, however fleetingly, you experience an unpleasant gut feeling. Because the *feeling is about the body, I gave the phenomenon the technical term somatic* state ("soma" is Greek for body); and because it "marks" an image, I called it a *marker*. … What does the somatic marker achieve? It forces attention on the negative outcome to which a given action may lead, and functions as an automate alarm signal… The automated signal protects you against future losses, without further ado, and then allows you *to choose from among fewer alternatives*. There is still room for using a cost/benefit analysis and proper deductive competence, but only after the automated step drastically reduces the number of options" (p. 173).

Damasio's example refers to cases where somatic markers act as an alarm bell if the outcome of actions is likely to be undesirable based on previous experience. They thus help to sift options in decision-making. But for resource activation in psychotherapy, positive somatic markers are also of interest. It is in these emotional reactions connected with positive somatic markers and accompanying bodily responses (good "gut feelings") that we now see the *neurobiological basis of the motivation system*. There is ample empirical evidence from motivational research in psychology that the forming of intentions is coupled with the emergence of positive emotions (GOLLWITZER, 1991, 1993). In Kuhl's personality psychological conception of the functioning of the psychological processes, positive emotions and motivation form a unit; Kuhl sees the ability of self-regulated recruitment of positive affect as the crucial determinant in self-determination and intrinsic motivation (KUHL, 2001, p. 177). Roth, as a neuroscientist, also sees this connection: emotions intervene in behavioral planning and control in that they play a part in the choosing of an action and promote certain behaviors; as "will" they energize actions during execution, and as fear and aversion they suppress others (ROTH, 2001, p. 7).

Somatic markers do not have to be perceived consciously to be effective, as DAMASIO (1994) demonstrated in "gambling" experiments with decks of cards (p. 212f.). The subject sits in front of four decks of cards, and the goal of the game is to lose as little as possible of a $2.000 loan. After playing from the four decks, which according to undisclosed rules pay out or require payment from the player, the player begins to have a gut feeling about which decks to play from. Before and beneath the conscious hunch that some decks are more dangerous than others, "there is a nonconscious process gradually formulating a prediction for the outcome of each move" (p. 214) and "telling the player that punishment or reward is about to strike" (ibid.). Damasio examined the physiological correlates of the nonconscious process, the somatic markers, by measuring skin conductance responses. All people possess this system of somatic markers and would show skin conductance responses in Damasio's experiment, but not everyone has bodily perception abilities that are sufficiently trained to consciously perceive the bodily signals. This fact also has consequences for psychotherapy.

KUHL'S (1998, 2001) theory of self-regulation examines in detail how insufficient discrimination of self-determined and externally determined goals are related to psychopathological symptoms. Psychological research provides ample evidence that self-congruent generation of goals (self-determination) more frequently leads to successful goal achievement than goals having low self-congruence (SHELDON & KASSER, 1995, 1998). Kuhl points out that the self-congruence of goals is monitored by a memory system that works in the implicit mode and is closely linked to bodily reactions. It thus makes sense to conceive of the signal system of somatic markers as the neuroscientific model of the specific abilities of the self-congruent person described by Kuhl, who has good perception of her own reactions and can organize her life accordingly. In this regard, Kuhl defines self-regulation as the ability to form and pursue self-compatible goals that are supported by positive emotions (1998, p. 66). Psychotherapy's task, accordingly, would be to provide proprioception training to people who are not able to perceive their somatic markers, in order to promote in the long term self-congruent generation of goals. There is an advantage here in that, according to Kuhl, the system of somatic markers is always active; what is underdeveloped or unlearned are only proprioceptive abilities. According to this, DOLAN (2002) identifies an urgent need to adress how the growth of emotional awareness informs mechanisms that underwrite the emergence of self-identity and social competence.

Another aspect of somatic markers is also crucial for psychology. Somatic markers are evoked not only in real situations, such as in Damasio's gambling experiments, but are also triggered when people think during phases of conscious deliberation and planning. DAMASIO calls this process the "as if" loop (1994, p. 174). As LEDOUX (1996) notes, in certain situations it is possible to imagine what bodily feedback would feel like if it appeared (p. 318). This is of course only possible if the brain has already experienced real feedback a number of times and thus can access knowledge that allows it to imagine how the feedback feels. The "as if" loop is particularly interesting for psychotherapy and the work with clients. Because of this phenomenon, it is safe to assume to that when clients consider behavior alternatives in the virtual experiential space of the therapeutic dialogue, the somatic marker system will be activated.

Somatic markers are highly individual, for they result from experience. DAMASIO writes: "The critical, formative set of stimuli to somatic pairings is, no doubt, acquired in childhood and adolescence. But the accrual of somatically marked stimuli ceases only when life ceases, and thus it is appropriate to describe that accrual as a process of continuous learning" (1994, p. 179). Naturally, somatic markers alone are not all that is needed for human decision-making. In this, emotion and cognition cooperate. The biological assessment system of somatic markers provides an initial qualitative ranking and pre-selection that is often, if not always, followed by logical reasoning and final selection. Damasio found that patients with lesions of the prefrontal cortex, the processing area for somatic markers, are not able to make decisions (BECHARA ET AL., 2000). They remain caught up in an endless process of cost-benefit analysis and never reach a decision. Damasio's studies demonstrate that emotions and their accompanying bodily states are thus an *integral part* of the decision process and therefore *indispensable* for rational behavior.

The finding that bodily sensations and emotions not only support decision-making but make them possible in the first place is exciting in its own right. But Damasio's findings have further consequences that are of particular interest to psychotherapy. Damasio's considerations, namely, accord remarkably well with the functions of the self system as viewed from a personality psychology perspective. For this reason, Kuhl, who is a motivation and personality psychologist, also refers to Damasio's concepts in his work on the functioning of the self system. According to KUHL (2001), the self system registers the personal relevance of behavioral consequences (such as their need satisfaction potential) and feeds this information into behavioral control in later situations. The information must represent not only previous actions and their results, but also the emotional reactions accompanying the results in an integrated manner. Without these emotional reactions, it would be difficult to choose among various previous responses when similar situations occur in the future (p. 153). The emotions experienced and associated body states, Kuhl notes, evidently belong to the signals that help the self system to decide among the behavioral options that have been tried out in the past (ibid., p. 153).

Expressed in the language of psychology, emotional experience memory, via the signal system of somatic markers, not only provides general support to decision-making, and not only helps to trigger motivation processes through positive somatic markers. Instead, it is a direct reflection of that which makes up our deepest experience of the self. This has the following consequence: the appearance of positive somatic markers is a direct signpost pointing to the topics, contents, intentions, and plans that the self system of the client supports. In this connection, therefore, somatic markers can be utilized as *diagnostic indicators of self-congruence*. They indicate whether the client experiences a decision made as consistent with the self. The advantage for psychotherapy in working with somatic markers as a diagnostic guide is that somatic markers are based on bodily states. This means that they are relatively simple to observe and measure and thus can be objective. Through the guiding system of somatic markers, the concept of "self," which is very difficult to operationalize, becomes more accessible to scientific research and therapeutic practice.

Conclusions

Neuroscientific perspectives have a dual relevance for psychology and psychotherapy. For one, the neurosciences can contribute to the grounding of psychological concept formation in an empirical basis. This became evident when we looked at, for example, the concepts of "the mind," "transference," "resource activation," "motivation," and "self-congruence," or "self system." On the basis of my work in the areas of personality theory, identity theory, and self-concept research as a researcher and therapist (STORCH, 1999). I am convinced that the field can only profit from a more uniform formation of concepts. Certainly, students would gain more rapidly an overview and understanding of the central variables in the field than is the case at present.

For another, the neuroscientific perspective has great integrative power for successful communication and mutual understanding among the various schools of psychotherapy, which I see as an important task for all practitioners and theorists in psychology who seek a future orientation in their work. The neuroscientific models of psychological regulation systems contain representations of all currently recognized directions in psychotherapy in their essential aspects – from behavior therapy regarding learning aspects to psychoanalysis regarding aspects of the unconscious. The view of man in humanistic forms of psychotherapy accords with the neuroscientific postulate that the human brain possesses the potential to assure psychobiological well-being and health and that this highly individual process, taking a constructivist approach, must be treated with respect. And all forms of therapy that work with body aspects in the broadest sense find in neuroscientific considerations a further empirical basis for their methods. All forms of solution-oriented therapeutic approaches find support in the concept of the automaticity of resource-activating neural networks.

In this sense the neurosciences can certainly not replace psychotherapy theory development, as they deal with only a part of the psychological system, namely, that part that can be tapped and described at the biological level. Mental/emotional experience, however, can in the end most assuredly not be described as a mere storm of neuronal activity or reduced to a few biochemical changes in the brain's metabolism. In the neurosciences, however, there is no such intention to do so. DAMASIO (1994) offers the following comment on the consequences of neuroscientific research for the particular importance and value of higher psychological processes: "Does this mean that love, generosity, kindness, compassion, honesty, and other commendable human characteristics are nothing but the result of conscious but selfish, survival-oriented neurobiological regulation? … That is definitely *not* the case. Love is true, friendship sincere, and compassion genuine, if I do not lie about how I feel, if I really feel loving, friendly, and compassionate" (p. 125); "Realizing that there are biological mechanisms behind the most sublime human behavior does not imply a simplistic reduction to the nuts and bolts of neurobiology" (p. 125f.)

In this way, therefore, psychology and psychotherapy should utilize the neuroscientific perspective as an integrating resource, without falling into the trap of biological reductionism. For psychology also has linkages to the arts and humanities, which are just as important for our understanding of human beings and the nature of human existence as are natural scientific findings.

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