Research Essay

Unconsciousness, Subconsciousness & the Creation of Consciousness

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Abstract

One of the most intriguing questions of mankind, if not the most intriguing one, is the question how consciousness arises. Answering this question requires examining the differences between unconsciousness, subconsciousness and consciousness. Especially important is the fact that there are multiple subconscious processes simultaneously, but only one conscious process. Conscious processes can become subconscious, and subconscious processes can become conscious. We show that the switchboard between consciousness and subconsciousness and so to speak the creator of consciousness is the subthalamic nucleus. And we propose a method by which the subthalamic nucleus might control consciousness, namely by monitoring the adrenaline levels of conscious and subconscious processes All principles regarding the creation of consciousness also apply to animals with a brain. We also show how the unique features of human consciousness - language and thinking - are realized neurally and how they are integrated into consciousness and subconsciousness.

Keywords: Unconsciousness, subconsciousness, consciousness, neuroplasticity, subthalamic nucleus.

1. Introduction

One of the most intriguing questions of mankind, if not the most intriguing one, is the question how consciousness arises. A special problem in finding answers to this question lies in the fact that the term "consciousness" has never been unambiguously defined. The primary definition of consciousness comes from the field of neuroscience. Neuroscience defines consciousness as a state of the brain where the person is awake and can initiate actions (Bear 2015). This definition of consciousness is also used in ordinary language. Philosophy often defines consciousness as a state where the person is aware of her personal experiences (Chalmers 1995, Chalmers 1997). It is obvious that it is difficult to find an explanation for a phenomenon which has not even been clearly defined.

What philosophers call consciousness might also be called phenomenal experiences. As phenomenal experiences they are indeed related to consciousness, but they are only a part of consciousness. The question if there is another layer of mental states that cannot directly be reduced to neural activity must be answered separately.[1] And there is a third meaning of consciousness, for example in a sentence like "I am conscious of my weakness." In this connotation consciousness is always related to language and has the meaning of knowledge. It should be emphasized that the first two kinds of consciousness exist in all animals with a brain as

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[1] It can be mentioned here that this has been done already by the author.

well whereas the third kind of consciousness only applies to humans. In this article we will concentrate on the "neuroscientific" consciousness and we will propose an unambiguous definition for the term "consciousness." First, we will explain how consciousness must be separated from unconsciousness[2] but also from subconsciousness.

We will explain how the different modes of the brain – unconsciousness, subconsciousness and consciousness – evolved evolutionary. This will lead us to definitions for the terms unconsciousness, subconsciousness and consciousness. Then we will show how consciousness is created. One conscious process is selected out of numerous subconscious processes by a special part of the cortex, namely the subthalamic nucleus (STN). The mechanism which STN uses might involve checking the adrenaline level of conscious and subconscious processes. Finally, we will show what the specialty of human consciousness is, namely language, and how language is realized in consciousness and subconsciousness.

2. Differentiation between unconsciousness, subconsciousness & consciousness

First, we would like to emphasize that most of the following considerations apply to all animals with a brain, not only to humans. Further down, we will come to the specialty of humans. As it is known, the brain works via neural connections (Bear 2015). Neurons[3] – these are the nerve cells of the brain – are highly interconnected and work by transmitting signals along these connections. Eventually signals are sent via nerves to muscles and initiate bodily movements.[4] Consequently the brain contains a huge network of neural connections. Most of these connections are fixed and don't change over the course of a person's lifetime.[5] For example, there are neural connections which control heartbeat or digestion.

Most activities of the brain work ***unconsciously***: that means they cannot (consciously)[6] be influenced. It is obvious that unconsciousness was the first mode of brain activities which evolution developed. If we use here the wording "evolution developed" we do this for clarity, not because we want to imply that evolution works teleologically. Of course, evolution works by trial and error. Mutations occur in some members of a species. If these mutations provide these members with an advantage for survival these mutations prevail and spread throughout the entire population until ultimately the entire species has developed a new functionality.[7] This also happened with the development of the first brains.

[2] Here we introduce a different meaning for the term "unconsciousness." As we will show in the following this meaning is absolutely necessary to be able to describe brain processes appropriately.
[3] There are different kinds of neurons, but the differentiation is irrelevant in our explanations.
[4] As we will see this definition is correct for all animals except humans. Humans have developed language and have learned to think. Consequently, in the case of humans, thoughts can also be considered to be actions.
[5] Except caused by aging and illness.
[6] We will explain the usage of this term "conscious" a little bit later.
[7] If the mutations are significant this leads to a creation of a new species.

At first, brains probably just contained a few neurons that controlled only one muscle function, maybe the aforementioned heartbeat or digestion. Because this concept proved to be beneficial evolution continued to use it. Finally brains evolved with numerous neurons that could control many different functions of the animal. Still today all vital functions of an animal's body are controlled unconsciously. And it has also to be mentioned that the vast majority of brain functions work unconsciously. That means that unconsciousness is the dominant mode of brain activities. As a definition for unconsciousness we can propose the following formulation: *Unconsciousness is a mode of the brain that uses fixed neural connections to control the vast majority of bodily functions including the functioning of the brain itself.* The emphasis lies on the fact the unconsciousness uses fixed neural connections.

But evolution discovered that the possibilities to develop new functionalities were limited if only fixed neural connections could be used. Consequently, evolution invented a new feature, namely neuroplasticity. Neuroplasticity is the ability of a brain to create new neural connections based on internal and external perceptions, also called sensations. Neuroplasticity only works in one special part of the brain, in the cortex, which is part of the cerebrum. In the cortex, new neural connections arise constantly. As an example we will look at a visual perception. When the eye is hit by an external image[8] a signal is sent to the cortex. Actually, during every second some 50 to 60 signals are sent via the visual nerve first to the thalamus, then from the thalamus to a special area of the cortex called the visual cortex. In the visual cortex these signals generate special neural connections, which we will denote as "neural patterns".

Consequently neural patterns represent the perceived objects in the brain. That means a huge number of visual perceptions – realized as neural patterns - is being created at every moment, all of which are characteristic for the objects we see. The same principle also applies to all other kinds of perceptions / sensations. As already indicated above, these sensations can either be external (such as visual perceptions or sounds) or internal (such as pain or hunger). All these sensations are registered ***subconsciously***.[9] Subconsciousness is obviously a mode of the brain in which the brain can process multiple sensations simultaneously and where the brain creates a large number of corresponding neural patterns.[10] What we see here is that neuroplasticity is the basis for memory and experience.

If a member of a species that has developed neuroplasticity encounters an event that was already experienced before the reaction to this event can be based on the fact whether the previous experience was good or bad. Consequently, neuroplasticity is also the basis for learning. But there is one caveat: When subconscious experiences first evolved, actions could only be initiated by reflexes. Consequently evolution developed a third mode of the brain, namely consciousness. Before we come to consciousness, we want to propose a definition for subconsciousness.

[8] When we use the word "image" here we mean the optical information which is emitted by an object and can be processed by an eye. We are not yet referring to what the brain does with this information.

[9] Visual perceptions are a little bit different. When our eyes are open we always integrate a part of our entire view into our conscious processing (The other parts of the view are indeed processed only subconsciously). That is the reason why we have to close our eyes when we want to sleep (while sleeping we are non-conscious). All other perceptions such as noises or smells don't prevent us from sleeping as long as they are not too intense.

[10] It must be mentioned here that subconsciousness is not yet very well investigated by neuroscience, compared to consciousness. One neuroscientist who investigated subconsciousness in more detail is Stenislas Dehaenne (Dehaene 1998, Dehaene 2003). But even Dehaenne is not really aware of the difference between unconsciousness and subconsciousness.

Subconsciousness is a mode of the brain, namely of the special area called the cortex, that uses neuroplasticity to create characteristic neural connections, neural patterns, based on internal and external sensations.[11] As we see, subconscious processes precede conscious processes.

Consequently subconsciousness was the second mode of the brain which evolved. As indicated, some of these subconsciously experienced sensations can cause direct actions. Examples are the withdrawal of a limb from a stinging object because of pain or the suckling of a baby at the mother's breast because of hunger. These instinctive actions are called "innate reflexes." Yet most subconscious processes do not initiate actions. But, as just mentioned, evolution developed another method to cause actions: evolution developed ***consciousness***.

We start here with a suggested definition for consciousness. *Consciousness is a mode of the brain in which the brain can initiate actions using internal and / or external sensations in potentially longer, complex processes.* This should now be an appropriate acceptable definition of "neuroscientific" consciousness. For the illustration of this definition we can use the example of a consciously hunting leopard. First the leopard experiences an internal sensation, namely hunger. This sensation activates a neurally stored program that the leopard has learned from his mother during his upbringing. He looks for prey, checks out cover, wind direction and distance to the prey and finally comes to the conclusion that the charge might be successful.

We see here two principles of conscious processing. First, different areas of the cortex can and have to work together in order to initiate actions. That means the different areas of the cortex have to be neurally connected. Second, at the end there must be a neural connection to the motor cortex because it is the motor cortex which sends signals via nerves to muscles thus initiating bodily movements. The group of neural connections which connect different parts of the cortex and finally initiate the motor cortex to send signals to muscles can all be called "neural processes". A neural process represents a learned behavior. When we look at the example of the hunting leopard we acknowledge that baby leopard has learned all these procedures from mother leopard. During this learning process baby leopard has imitated mother's behavior and has thus built new neural connections which finally enable baby leopard to hunt autonomously.

Now it has to be emphasized again that there always exist multiple subconscious processes simultaneously but there can only exist one conscious process. The reason is evident: only one action can be initiated at a time. Otherwise contradictory actions could occur such as moving in opposite directions. We now can extend our definition of consciousness: *Consciousness is a mode of the brain in which the brain can initiate actions using internal and / or external sensations in potentially longer, complex processes. There can always only exist one conscious process.* What we have seen here is that conscious processes initiate actions. What we see here as well is that consciousness requires wakefulness while subconsciousness does not. Consequently, we have to introduce another term, namely non-consciousness.

While we sleep we are in a state of non-consciousness. We are also in a state of non-consciousness when we faint or when we are sedated. And of course, we are also in a state of non-consciousness when we are in a coma. But in all states of non-consciousness our subconsciousness is still more or less active, with the possible exception of a coma. Here we now have to emphasize that subconsciousness cannot only create neural patterns, but subconsciousness can also – like consciousness – use neural processes. Consequently, we must

[11]A little bit later, we will see that we still can extend this definition, namely after consciousness was developed.

extend our definition of subconsciousness proposed above: *Subconsciousness is a mode of the brain, namely of the special area called the cortex, that uses neuroplasticity to create characteristic neural connections, neural patterns, based on internal and external sensations. Subconsciousness can also use neural processes. There can always exist multiple subconscious processes.* As we see, without subconsciousness we could not perceive sensations. But because subconsciousness can also use neural processes, subconsciousness can do even more: when we sleep subconsciousness creates these wonderful mysterious experiences which we call dreams.

In order to better understand the interaction between consciousness and subconsciousness it must also be mentioned that besides innate reflexes there are some more cases where subconscious processes can initiate actions via the motor cortex. A good example is walking. As a baby we have to consciously learn to walk. We have to focus our consciousness on every step and on keeping balance. After we have learned to walk everything is performed subconsciously. A former conscious process has become subconscious. The same principle applies to car driving. That means that subconscious processes can cause some more body movements; we can call these movements "learned reflexes." Again, most subconscious processes do not initiate actions and serve more the purpose of information gathering. Still, we see here that conscious processes can become subconscious. As we will see a little bit later, subconscious processes can also become conscious and conscious processes can become subconscious. Summarizing we can say that there are three different modes of brain activity: unconsciousness, subconsciousness and consciousness. As already mentioned, we can assume that they developed evolutionarily in this order. And we have to emphasize again that all these principles apply to all kind of animals with a brain as well.

3. The creation of consciousness and the role of the subthalamic nucleus

Consciousness and subconsciousness are closely related. Both use neuroplasticity. Both have basically the same structure. Neural connections which are caused by sensations and which we have called neural patterns become interconnected and signals are transmitted along these connections. These processes we have called neural processes. Some of the subconscious processes initiate actions directly as in our example of walking, but most of these processes only gather information. Now it has to be mentioned again that subconscious processes can become conscious and conscious processes can become subconscious, as already indicated above. First we will look at a well-known example where a subconscious process can become conscious.

We mentioned above that we also perceive auditory sensations in a state of non-consciousness, namely when we sleep. And we also mentioned that we can tolerate noises while sleeping only if they are below a certain threshold, if they are not too loud. A noise which becomes too loud is the ringing of an alarm clock. When we register, first subconsciously, the ringing of the alarm clock this process eventually becomes conscious and we know that we have to get up. Also, an unusual smell, such as smoke, would wake us up. A different example is the experience that we cannot remember a name. We try consciously, but eventually we give up and think about something else.

Now our conscious name-searching process becomes subconscious and something else becomes conscious. After some time, all of a sudden the name comes up. The brain has subconsciously continued the search and was finally successful. Now this process becomes conscious again and

the previously conscious process becomes subconscious.[12] Obviously there must be a switchboard between subconscious and conscious processes. Subconscious processes can send a kind of a signal to this switchboard and when the signal has a certain signal strength the switchboard makes the subconscious process the conscious process and makes the former conscious process subconscious. But what is the switchboard?

Recent studies (Aron 2006, Kuhn 2004, Ray 2012, Wessel 2013) focused on activities of the brain during distractions. Test persons had to perform special manual tasks and were distracted by some unusual signals which then led to a decrease in their performance (motor stopping). The studies measured brain activity during these tests. These studies showed that the subthalamic nucleus (STN) is very active when test persons are distracted while performing an action. Wessel et al. later investigated distractions of cognitive processing which affected the verbal working memory (Wessel 2016).

This time test persons had to perform some cognitive tasks. Sometimes they were exposed to a sine-wave tone that was familiar to them. This had no effect on their performance. In other cases a surprising bird song was played which so distracted the test persons that they could not perform their task as well as before. Again Wessel et al. determined that the STN is especially active in the case of cognitive distractions. Wessel et al. concluded that distractions (unusual external sensations) activate the STN during both motor tasks and cognitive tasks. What Wessel and his colleagues were not aware of is that they had found the switchboard which creates consciousness: the subthalamic nucleus![13]

The issue is that Wessel and his colleagues are not aware of the relations between conscious and subconscious processing that we have laid out above.[14] As we have explained, the cortex performs one conscious process and multiple subconsciousness processes simultaneously. Now we can assume that the STN controls which process is conscious. The STN also controls all subconscious processes. All subconscious processes send signals to the STN. When a given subconscious process reaches a certain signal threshold the current conscious process is interrupted. This can be just a distraction as in the cases investigated by Wessel and his colleagues. But it is also possible that the STN switches from the previously conscious process to a previously subconscious process and thus makes the latter the new conscious process.

We have illustrated this principle with our example of searching for a name. This must apply to all kinds of consciousness processes regardless whether they involve motor actions or are cognitive processes. Summarizing we can say that the cortex performs many subconscious processes simultaneously. The STN controls the subconscious processes and selects one as the conscious process. The STN creates consciousness. Whereas consciousness requires

[12] Actually, this is an example that uses a special human feature, namely language. But it has to be emphasized that the principle of switching between consciousness and subconsciousness also applies to all animals with a brain.

[13] Now we have a situation which can be compared to that of Arno Penzias and Robert Wilson when they discovered the cosmic microwave background radiation in 1964. Penzias and Wilson had measured some microwave radiation they could not explain. Later they learned that they had found the cosmic microwave background radiation, which was created 380,000 years after the big bang. The existence of the cosmic microwave background radiation was first predicted by Alpher and Herman in 1948.

[14] Actually, this must be said about neuroscience overall. Neuroscience has not yet realized that subconscious and conscious process are basically the same, and that a single one of all subconscious processes is privileged for a given time. This privileged process becomes conscious. This article is the first time, these principles have been outlined in this clarity.

wakefulness, subconscious processes such as perceiving noises or smells are performed even during sleep. But the STN can also wake someone up. Normal noises are tolerated by the STN during sleep. But when a noise gets too loud - such as the ringing of an alarm clock - the STN wakes the person[15] up and activates consciousness. The conscious process then again has the privilege to initiate actions whereas during sleep no actions take place. During sleep – a state of non-consciousness – no actions can be initiated. Only innate reflexes occur during non-consciousness.

Now the question is how the STN decides that a subconscious process shall become conscious and what kind of signal might be sent from all conscious and subconscious processes to the STN. Here we can remember a neural mechanism which is used to increase awareness and responsiveness, namely the enhanced creation of adrenaline. It is known that the perception of something which is new, different or negative leads to an automatic increase of the production of adrenaline. We can now assume that all conscious and subconscious processes are accompanied by a certain adrenaline level. Especially conscious processes should always be accompanied by a certain adrenaline level, because conscious processes have the task to initiate actions. And it can also be assumed that the initiation of actions always needs a certain adrenaline level.

Now we can further assume that also subconscious processes are accompanied with a certain adrenaline level as well. But obviously this level is lower than the adrenaline level of the current conscious process. When something special happens in one of the subconscious processes, it is probably accompanied by increased production of adrenaline. This is very plausible for our example of the ringing alarm clock, and it also very plausible for a situation with an unusual smell. In both situations there is something perceived that is different than the expectation. But we can also assume that the adrenaline level is increased in intellectual subconscious processes, for example in the subconscious search for a name. When the subconscious process that searches for the name finally found the name, subconsciousness got so excited, so to speak, about the success that it consequently produced more adrenaline. Then the STN realized that there is a subconscious process that is suddenly producing an unusually high level of adrenaline, obviously higher than the adrenaline level of the current conscious process. So the STN makes the former subconscious process of name searching the conscious process. Now the new conscious process can "present" the result of the search.

Consequently we can say: the subthalamic nucleus creates consciousness.

4. Human consciousness

Even though we have used some examples involving human activities such as searching for a name, we have to emphasize that everything said to this point also applies to all animals with a brain. Also in animals with a brain unconscious processes control the biggest part of the organism. Also in animals with a brain there are many subconscious processes which are caused by internal and external sensations. Also in animals with a brain there exists just one conscious process. And also in animals with a brain the STN switches between subconsciousness and consciousness by checking the adrenaline level. The only unique specialty of humans is our advanced declarative language.

[15] Or an animal in a similar case

We now have to mention that neural patterns created by sensations in animals can also be denoted as imaginations. These kinds of neural patterns are, of course, also created in humans. When humans developed language they started to associate terms with imaginations. Neurally two additional kinds of neural patterns are created.[16] We can call these additional neural patterns language-representing neural patterns or neural language-patterns. The first neural language-pattern is an audible neural pattern. When a person hears a word an audible neural pattern is created and a neural connection to the corresponding neural pattern representing the imagination of the object is activated. The person knows what the word means. The second language-pattern is a neural speak-pattern.

When a person wants to speak about an object a neural connection from the neural pattern for the imagination of the object to a neural speak-pattern is activated. The neural speak-pattern then sends signals to the speaking-apparatus which produces the corresponding sounds.[17] Later during the evolutionary development of human language humans also developed terms which are no longer connected to imaginations but are instead defined by other terms. This stage can be called the second level of abstraction. [18] Consequently some neural language-patterns are only connected to other neural language-patterns. Furthermore, in the evolutionary development of human language humans also learned to speak silently to themselves. Silently speaking to oneself is thinking!

Now humans could think without using their speaking-apparatus. We experience the connection between thinking and speaking in every waking moment, because we cannot think without speaking silently to ourselves. The connection between auditory neural patterns and understanding is confirmed by the fact that auditory neural patterns are created in a special part of the cortex called the temporal lobe (there in the auditory cortex). In the temporal lobe we also find the Wernicke area which is known to play a role in understanding. The connection between neural speak-patterns and thinking is confirmed by the fact that neural speak-patterns are created in a different part of the cortex, namely in the frontal lobe (there in the motor cortex). In the frontal lobe, we also find the Broca's area which is known to play a role in formulating language. Generally, the frontal lobe is known as the area of cognition. An as we explained, cognition is performed using language, using neural speak-patterns.

We have mentioned before that the result of a conscious process is the initiation of an action. With the development of language that action now can also be just the creation of a thought, again realized as neural language-patterns. Consequently language has now to be incorporated in consciousness, but also in subconsciousness. As an example for the incorporation of thinking into subconscious processing we have already used the case of name searching. For a while we conducted a conscious search process for the name which included the use of neural language-pattern. Then we turned our attention to a different conscious process. But the brain still continued the search process, namely subconsciously, also using neural language-patterns. This is thus a subconscious neural thinking process. When this subconscious neural thinking process succeeds in finding the name it becomes conscious again and supersedes the previous conscious process.

[16] These principles are very deeply elaborated by the author in his book.
[17] Actually, these principles even apply to animals in situations where animals have developed signal languages.
[18] An example for the second level of abstraction is the term "fruit." Whereas terms of the first level of abstraction such as "apple" or "banana" are still connected to an imagination, the term "fruit" is not anymore.

As we have explained above the subconscious process has produced a signal to the STN and the STN has made the former subconscious process conscious. Subconscious thinking processes are also the basis for creativity. We can think about a problem and maybe do not find a solution. Sometime later, we suddenly have a solution in mind. The brain has subconsciously continued to think about the problem and eventually has found a solution. But there is more: subconscious thinking also occurs during sleep.

There is one really amazing example from the author's experience. The author and his wife had dinner with a befriended couple in their favorite steak house in Palm Beach, Florida. They were served by their favorite waiter. As usual, both couples split the check. Normally, the author checks the total amount of the check and calculates 10% of it. This would be the tip for each party (20% in total). But this time the check was already split in half and the author calculated 10% of the half amount for each party. That means that the waiter only got 10% tip. The next day the author and his wife flew back to Germany. Two days later, the author woke up in the middle of the night. All of a sudden he had realized that he had calculated the wrong tip. That means that the author's subconsciousness still had thought about the event and had recapitulated the author's mistake.

When the subconscious mind realized that this mistake had occurred it sent a signal to the STN and the author woke up. Now the previous subconscious process which had discovered the mistake suddenly had become conscious! But imagine: This happened two days later on a different continent and the author had not thought about the situation in the meantime! How powerful is subconsciousness! Indeed, it is not surprising that subconscious processes also include thinking. Above we have laid out that conscious and subconscious processes have basically the same structure and use the same areas of the cortex. And because human conscious processes can include thinking, this must be true for human subconscious processes as well. Consequently it is indeed possible that ideas or thoughts can be subconsciously created during sleep. Then the subconscious process might send a signal to the STN so that the STN wakes us up. Otherwise we might forget the ideas and thoughts again. We also forget most of our dreams. What we have seen here is that thinking is also part of subconscious processing and that even here the STN is in control.

Now we can even assume that some mental diseases such as schizophrenia might be caused by a malfunction of the STN. And STN could also play a role in the case of a persistent vegetative state. In the case of a persistent vegetative state a person is awake and seems to react to some external perceptions. But these reactions are obviously reflexes and not conscious actions. Now we must consider the possibility that a persistent vegetative state might be caused by a malfunction of the STN. Subconsciousness still works to some degree; the person perceives some external sensations. But the STN can no longer make one of the subconscious processes conscious. Consciousness can no longer be created out of subconsciousness.

5. Conclusion

The first major aspect of this essay was to explain the distinction between unconsciousness, subconsciousness and consciousness. Conscious and subconscious processes have the same structure and use the same areas of the cortex. Conscious and subconscious processes occur only in the cortex whereas unconscious processes occur in all other parts of the brain and can occur in

some parts of the cortex as well. We subsequently explained that there are multiple subconscious processes all the time – even in a state of non-consciousness such as sleep - whereas there can always be only one conscious process. Obviously the cortex selects one of the subconscious processes and makes it conscious. But the cortex can also switch to a different subconscious process and make this one conscious. As recent research suggests the part of the cortex which switches between conscious and subconscious processing is the subthalamic nucleus (STN). That makes the subthalamic nucleus the creator of consciousness. We further assumed that the STN works by monitoring the adrenaline levels of conscious and subconscious processes. The process with the highest adrenaline level becomes conscious.

The claim that the STN is the switchboard between consciousness and subconsciousness should be easily confirmed by experiments. It is necessary to measure the activity of the STN during different stages. When a test person is awake the STN should be active. As the investigations mentioned above have already shown the activity will increase when the test person is permanently distracted, either during manual or cognitive tasks. When a test person falls asleep the activity of the STN should decrease. But there should still be some activity because the STN has to monitor the subconscious processes.

When a test person is sedated the activity of the STN should decrease even more. It may remain active at a certain level because subconscious processes occur even when a person is sedated, but something must prevent the STN from waking the person up! Finally there should not be any activity at all when a person is in a coma, including a persistent vegetative state.[19] Simultaneously the adrenaline level should be measured. Because we have shown that everything (except language) which can be said about human consciousness / subconsciousness is also true for animals' consciousness / subconsciousness, all these experiments can also performed with animals, especially with monkeys. It might even be possible to design appropriate experiments for some cognitive activities with animals.

The only aspect unique to humans is our declarative language. But as we have shown here the principles of conscious processing also apply to language. In addition to neural patterns caused by sensations language-representing neural patterns are formed. These language-representing neural patterns can be included in conscious processing leading to thinking. And we have also shown that subconscious processes use neural language-patterns as well; that means that we can even think subconsciously.

Finally there is an additional issue in which our considerations might shed new light. The famous experiments of Benjamin Libet suggested that unconscious processes in the brain are the true initiator of volitional acts. (Libet 1985) In the following years it was suggested that the limbic system which indeed interacts unconsciously with the cortex is the true initiator of actions. But now we could also assume that decisions are made by the subconscious mind, and actions are already initiated before the STN makes the subconscious decision process the conscious process. Even if this distinction might look irrelevant at first sight there is one major implication: If a decision is indeed made unconsciously by the limbic system this decision is more or less random. But if the decision is made by subconscious processes we can assume that the decision is made based on good reasons, because we have learned that subconsciousness also performs thinking and reasoning!

[19] This assumption is of course only true if the STN has no other task but switching between subconsciousness and consciousness

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