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Analýza biologických a psychologických markerů u lidí s chováním zdraví podporujícím a lidí s chováním zdraví ohrožujícím

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Abstract
Confirming or refuting the hypothesis that a psychological phenomenon is a specific phenomenon of a quantum nature (SQC – phenomenon) with a non-linear character and more than eleven-dimensions is not possible within the framework of a single research project. The demands for the research are increased due to the fact that we have at our disposal diagnostic tools which are capable of measuring phenomena of only linear nature. Despite that, our research aims to reach the essence of human psyche and the mechanisms which ensure the functioning of a live, self-organising, self-regulating and self-aware phenomenon (self – core) on a macroscopic level. This study represents a probe into the research project and the formulation of research strategies for studying complex psychological phenomena in coincidence with their material bearer, the human brain.
In the first stage of research, we work with two groups of people: those exhibiting health-enhancing behaviour and those exhibiting health-threatening behaviour. We suppose that the realisation of the research project will allow us to obtain and process data regarding the differences in the complexity of neuronal structures and the differences in their connectivity to the selected psychological phenomena in people exhibiting health-enhancing behaviour when compared to those exhibiting health-threatening behaviour. For research of the ratio of biological and psychological markers in human behaviour, we see as paramount the analysis of the relationship between the altered parameters of neuronal complexity in the relevant neuronal structures. We expect that it is this data on morphological differences and altered parameters of neuronal complexity which attest to the contributing biological factors (genetic, endocrine and metabolic) and external contributing environmental conditions. Ultimately, our interest is in knowing how these altered parameters affect the degree of coincidence of neurophysiological and psychological phenomena.

Key words
health-enhancing behaviour, health-threatening behaviour, biological markers, psychological markers.

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Abstrakt
Potvrdit nebo vyvrátit hypotézu, že psychický fenomén je specifický fenomén kvantové povahy (SQC – phenomenon), který má nelineární povahu a je více než jedenáctirozměrný, je nemožné v rámci jednoho výzkumného projektu. Zvýšené nároky jsou dány skutečností, že máme k dispozici takové diagnostické nástroje, které jsou schopny měřit pouze jevy lineární povahy. Přesto chceme v naší výzkumné činnosti dospět k podstatě lidské psychiky a k mechanismům, které zabezpečují fungování živého, sebeorganizujícího, seberegulujícího a sebe si uvědomujícího jevu (já – core) na makroskopické úrovni. Tato studie představuje sondu do vlastního výzkumného projektu a do formování výzkumných strategií pro zkoumání složitých psychických jevů v koincidenci s jejich materiálním nositelem, lidským mozkem.
V první etapě výzkumu pracujeme se dvěma skupinami lidí, a to s lidmi vykazujícími zdraví podporující chování a s lidmi projevujícími zdraví poškozující chování. Předpokládáme, že realizace výzkumného projektu nám umožní získat a zpracovat data o odlišnostech v komplexitě neuronálních struktur a současně o odlišnostech v jejich konektivitě s vybranými zkoumaných psychických jevů u lidí s chováním zdraví podporujícím oproti lidem s chováním zdraví ohrožujícím. Za prvořadé ve výzkumu podílu biologických a psychických markerů v chování člověka považujeme analýzu vztahu mezi změněnými parametry neuronální komplexity příslušných neuronálních struktur v důsledku časté a nadměrné až patologické emoční zátěže, které jsou od dětství vystaveni lidé s chováním zdraví ohrožujícím, oproti lidem bez této zátěže a bez těchto změn a s chováním zdraví podporujícím. Předpokládáme, že právě data o morfologických odlišnostech a změněných parametrech neuronální komplexity rovněž vypovídají o spolupodílejících se biologických faktorech (genetických, endokrinních i metabolických) a o vnějších, spolupodílejících se environmentálních a ekologických podmínkách. A v konečném důsledku nás zajímá, jak tyto změněné parametry ovlivňují míru koincidence neurofyziologických a psychických jevů.

Klíčová slova
chování zdraví podporující, chování zdraví poškozující, biologické markery, psychologické markery

Introduction

Musings on the psyche as a quantum phenomenon date back to R. S. Hameroff and R. C. Watt (1982), R. S. Hameroff and S. Rasmusses (1990), F. Beck and J. Eccles (1992), R. Penrose (1999), H. Atmanspacher et al. (2004), and more. These are the principal hypotheses. However, in the new paradigm of viewing the essence of the human psyche, it cannot be unequivocally said that psyche is a quantum phenomenon; it is, however, quantum in nature (Vašina, 2011, 2013). It is a qualitatively different phenomenon which is alive and simultaneously capable of self-awareness. It exhibits the properties of both waves and particles. We also take in to consideration the structures which are able of "carrying" psyche as a phenomenon of quantum nature, such as microtubules. In this respect, we were inspired by R. S. Hameroff and R. C. Watt (1982), S. R. Hameroff, S. Rasmusses (1990) and other neuroscientists.

On one hand, our reasoning for psyche as a phenomenon of quantum nature has freed psychological phenomena from causal dependency and linearity. Psychological phenomena are non-linear in nature. Each such wave is governed by the principle of independence of waves in space and the principle of interference. Different waves (with different frequencies of oscillation) spread as if there were no other waves around,

despite that not being the case. These different waves do not gradually meld together, but interfere, which is expressed in the specific product of permanent mental activity which, in the absolute sense of the word, is not hic et nunc immediately dependent on the activity of the given neuronal network. On the other hand, we are forced to consider the space-time where such events can take place. The assumption is that in the case of the human psyche, in the case of intrapsychic space in which the content of consciousness takes place and even in cases of consciousness itself, we are dealing with a live, more than eleven-dimensional phenomenon of a quantum nature with a very specific configuration of waves. The problem is that such a time-space cannot be mathematically described by a real number.

The fact is that, for instance, prefrontal lobes (through the connection with other CNS structures via neuron networks) and the mental functions generated within play an important role in the manifestation of self, personality and self-awareness. The prefrontal cortex is also the structure which "carries" the so-called social extension of the human psyche, meaning empathy, self-reflection, flexible adjustment, moral values, higher emotions, eroticism etc. From the activity of the prefrontal sections of the anterior lobes also comes initiative, affiliative and assertive behaviour, the ability to predict, pose questions, create hypotheses etc. All these are psychological phenomena, while neuronal activity, waking, is a neurophysiological phenomenon. Neurophysiological and psychological phenomena are not one and the same. The key is in understanding the distance or proximity between them and understanding the mechanism of their mutual connectivity. Even the phenomenon of personality is not a mere configuration of action potentials oscillating at high speeds in neuronal networks. The mechanisms stored in the prefrontal zones and neuronal networks, or the neuronal activity alone is not capable in and of itself of ensuring in each moment such a temporally stable and high-integrity phenomenon as personality, as the **self**. Conclusions on personality cannot be made even from the analysis of prolonged activity of structures such as RF – ARAS or other, albeit intricately connected CNS structures. For example, even a person with an extreme case of hydrocephalus will exhibit specific characteristics of personality, which refutes locationist tendencies in theoretical reflections on the extent to which the phenomenon of personality is embedded in specific structures of the CNS. Similarly misleading are the assertions of some representatives of neuroscience regarding the existence of emotive neurons which communicate between themselves which one is "sad" and which one is "happy". Which neuron, then, would "shoulder" the weight of anger, hate or empathy? We would also have to account for rational neurons, neurons with the sense of self etc. Such stories belong on the pages of fantasy books. It is not the neurons whose dendrites receive APs and after evaluation send them to other sections of the CNS, but the working constellations of neurons (nuclei, nuclear complexes) which are embedded and mutually communicating within neuronal networks. The neuronal networks are the ones specialised in providing the manifestations of certain mental functions (though due to the possibility of competitive neuroplasticity, this may not be true in all cases). Each function has its processual side. In addition, many neuronal structures (the hippocampus, for instance) represent the input nodes into the relevant neuronal networks which are mutually interconnected in terms of communication. These neuronal structures have a 3D spatial arrangement. This is the material base from which psychological phenomena are generated. The oscillation taking place here, the very rapid events which are

well energetically provided for, allow the creation of psychological phenomena via translators (which, so far, remain insufficiently described in scientific literature). Though, for example, G. Buzsaki and A. Draguhn (2004) and S. Grillner, A. M. Christen (2004) and others have framed principal concepts regarding the oscillation in neuronal networks and interference between neurons and global brain functions, they have not yet tackled connectivity with psychological functions. Why the main information stream and meaningful information processing goes through specific structures and in a specific direction in each present moment (hic et nunc) is decided in the hierarchical arrangement of regulatory mechanisms of the human psyche by the self (core) as the highest instance. Each human activity always has its motive, intent and goal. It is the final direction of the person hic et nunc which is decided by the self as the core of the personality. Only in pathology may this not be the case.

Dissociation of the self from self, self-awareness is not in the competence of action potentials, nor only in the potential of neurophysiological phenomena. Such is only possible in the intrapsychic space which is in itself more than eleven-dimensional. It is especially the self, the psychological phenomenon, not the action potential, who can, for example, by decision, "kill with word its material carrier", i.e. kill itself, similarly to what is possible in some of the so-called dark cults using black magic. The word associated with ritual then becomes a key, a trigger of neurophysiological processes in the content of the mind of a manipulated person, which leads to his or her death. Literarily said, word can not only please, but also "kill" its material carrier.

Unfortunately, the manifestations of the human psyche are often seen in research as linear events, as immediate cause and effect, as the activity of gradually activating subsystems of the psyche ensuring, ultimately, the resulting behaviour "where it all ends in the given context". Sic! Therefore, the manifestation of the human psyche is in this case merely the sum of subsequent activities of its individual subsystems. The result would be a person functioning as a servomechanism. Therefore, the hypothesis of approaching the human psyche as a phenomenon of a quantum nature seems as a positive shift in the paradigm of the essence of the human psyche.

Our original paradigm of thinking about the relationship between the neurophysiological and the psychological phenomena, as a basis for the establishment of a research project, builds upon the latests findings of neurosciences regarding the relationship between the brain and the mind. There are many obstacles along this road of scientifically resolving the basic issue of neurosciences and psychological sciences, which have to be addressed in parallel in multiple disciplines. One of these obstacles is the fact that only the minority of neuroscientists and psychologists is willing to accept that the human psyche is in fact different from everything we have so far been capable of revealing, analysing and understanding using instrumental methods. We have so far been unable to reach a definite consensus that a psychological and a neurophysiological phenomenon are not one and the same. These are not simply different points of view or different levels of thinking when researching the nature of mental functions and their connectivity with the relevant configurations of working constellations of neurons. Understanding the basic differences on one hand while understanding the coincidence between neurophysiological and psychological phenomena on the other is key for further scientific analysis of the relationship between the brain and the human psyche, the brain and the personality. Otherwise, we have no way of understanding how, in each instant, the massive amount

of sensitive, sensory and motoric information about each object and phenomenon of reality and one's own body, its activity etc., is simultaneously serially and parallelly distributed via the neuronal network and sequentially processed so that the stability and continuity of mental events, the flow and feeling of wholeness and meaningful existence of the human being in the present are not disturbed. We will not grasp how the information flowing through the simultaneously active receptive points of neurons in various CNS structures interact with past experience and enable an outlook to the future, only to eventually link together in a permanently perceived and realised coherent continuous process (taking place in the content of consciousness). All that with the unique experience of "it is happening to me". The conscious content in this process is decided by a stable, consistent phenomenon: the personality, with the self as its core. The self (core) has, inter alia, an integrative function in the quantum field, which allows it to interconnect those functional systems which process information of past, present or future nature. In each moment, each constituent element of such a compact phenomenon of a quantum nature incorporates also the information about the whole of which it is a part. That is possible only in a quantum field. It is the only way of explaining that bioelectrochemical processes, which lie in the very core of neurophysiological phenomena (such as being awake), do generate psychological phenomena (such as content of consciousness) but, logically, cannot be identical to them. However, psychological phenomena are as real as bioelectric and biochemical phenomena and thus as real as neurophysiological phenomena. Current diagnostic methods, whether they be psycho-diagnostic methods, neuropsychological test batteries or EEG, fMR, PET, SPEC and other displaying techniques, do not allow us to reach the understanding of the essence of the human psyche merely on the basis of gradual measurement and evaluation of data on the individual psychological phenomena. The activity of the substructures of personality or the manifestations of personality characteristics and traits in the human behaviour are not a result of a simple sum of subsequent activities of individual subsystems of the human psyche, and are regulated by the same interactive and space-time principles as self-awareness in the integrity (including physical self-concept) of the content of consciousness. In addition, it is that much more difficult in this dynamic and changing process to discover the mechanisms ensuring in each instant the stability and constancy of the most complex psychological phenomenon of all: the self as the core of personality. From these facts also follows how difficult it is to analyse changes in the parameters of neuronal complexity as a result of negative outer and inner influences on the material basis of psychological phenomena over the course of human life. It also follows how difficult it is to analyse the extent of neuron connectivity with real self-awareness and adaptive or maladaptive human behaviour in each instant of real time. The analysis of mechanisms and principles contributing to the existence of a temporally stable real psychological phenomenon, the self, presents a chance for a scientific shift in the knowledge about human psyche.

We again stress that the core problem of neuroscientific and psychological diagnosis lies in the fact that we have at our disposal diagnostic tools which measure only linear phenomena, but lack tools which would allow the observation of phenomena which are non-linear in terms of the space-time parameter.

Despite this, our research project has probed at the elementary level and made the first step which, at the conclusion of the research, will lead to the confirmation or refutation of the hypothesis regarding human psyche as an SQC - phenomenon.

Method

In the first stage of research, we work with two groups of people: those exhibiting health-enhancing behaviour and those exhibiting health-threatening behaviour. These are two taxonomically different types of people. We assume that, in the case of people exhibiting health-threatening behaviour, the behaviour is motivated on one hand by the unfavourable inner biopsychological conditions, partially genetic in nature, but above all by those created as a result of negative influences in the family environment (negative parenting style, so-called broken home etc.) in the sensitive periods of ontogenesis. Adverse inner biopsychological conditions, however, can also be reinforced by negative environmental influences during the entire life of a person. In people exhibiting health-enhancing behaviour, we assume that their behaviour is conditioned by both favourable inner biopsychological influences and favourable environmental influences. We expect that our research will allow us to obtain and process data regarding the differences between the studied psychological phenomena and the changes in people's behaviour in association with the changes in the parameters of their neuronal complexity as a consequence of intense emotional stress which some of them have been experiencing since childhood. At the same time, we want to obtain and process data on the connectivity of neuronal activity of the affiliated neuronal structures with psychological phenomena. The focus are the correlations between a deficit in neuronal activity and the amount of stress experienced. Emotional traumas, unresolved conflicts, psychological tension, high stress level, low frustration tolerance, negative emotions and health-threatening behaviour intensify limbic irritability. Limbic irritability leads to a deficiency in the inhibition systems, an imbalance in neuronal dynamics, a change in the parameters of neuronal complexity and even a disruption of neuronal connectivity with psychological phenomena.

For the analysis of biological markers, we used EEG in the Centre of Neuroscience – CEITEC MU, under the erudite professional guidance of M. Mikl and M. Lamoš. We were particularly interested in the dynamic neuronal activity of the dorsolateral and ventromedial portion of the prefrontal lobe (inter alia the activity of cortico-subcortico-cortico circuits, specifically the dorsolateral and orbitofrontal circuits generating executive functions, deliberate attention, working memory and others), as well as the activity of the anterior cingulate cortex (ACC) in the connectivity with anterior zones, providing emotional modulation of information directed to the cerebral cortex, the activity of the parietal cortex and temporal cortex and the primary vision zones of the cortex and the SMA zone connected to BA 4, 6, 1, 2. The unanswered question is how non-linear mental functions are generated from linear neuronal wave activity, its significant global oscillations and its oscillations associated with current stimulus situation during conscious cognitive activity. We are interested in the relationship between EEG rhythms (EEG topography obtained over the course of 5 minutes with predominant microstates – maps) and the data obtained by selected psychodiagnostic methods. Cluster analysis of EEG topography was used to analyse the predominant microstates – brain maps from a total of 300 thousand microstates in the course of 5 minutes (i.e. a thousand microstates per second with different wave sizes listed in microvolts). Using this method, we obtained 5 to 6 predominant maps for each proband which revealed the state of neuronal structures and the neuronal activity in a situation where the proband did not have to solve any tasks. Such a person is awake, but shows low attention activity, does not have to "do any-

thing" and remains passive in this first step, since he or she is not tasked with deciding between indifferential visual stimulus and a critical (target) visual stimulus and react to it with movement. It is a state akin (though not identical) to the DMN state (Default Mode Network). Therefore, our follow-up research will focus, inter alia, on the analysis of the relationship between the beta band and the areas of DMN and will verify the hypothesis that the DMN represents a "closed entrance" to the content of consciousness for a certain type of information, as is the case, for example, in people with autism and other diagnoses with similar clinical image in some aspects. DMN is typified by a spontaneous low neuronal activity where the brain is awake, but the person is not reacting to stimuli from the environment, since information "flows through" his or her consciousness as if it were only insignificant information. "The person knows and does not know of the information" at the same time. On the behavioural level, the person shows low attention activity towards the surroundings.

Only in the second step did we focus on the study of cognitive evoked potentials (ERP), especially the effect of the P300 wave evoked during the process of decision-making and cognitive solution of a so-called oddball task. To determine the state of the neuronal base of the psyche, the study of ERP appears pivotal. In this context, it must be emphasised that our theoretical background was drawn from articles of prominent neuroscientists working in the research centre in Brno (CEITEC). These include, for example, M. Bareš, I. Rektor et al. (2000), M. Bareš (2001, 2011), A. Damborská et al. (2015) and more. Many pieces of knowledge were also obtained during personal consultations and seminars led by M. Kukleta (2014). Cognitive evoked potentials/event-related potentials (ERP) are suitable for the study of neuronal complexity and the connectivity between neurophysiological and psychological phenomena, as well as the analysis of the differences in their parameters in people with different personal histories and degrees of stress load. ERPs are generated from complex neuronal networks and their current restructuring into modules of working constellations of neurons as a response to a current stimulus situation in which the person finds him/herself at the moment. It is a material component of both conscious and unconscious mental activity, where a stimulus is detected and a response to it is cognitively processed. The most notable phenomena are P300 waves, MMN (mismatch negativity) and CNV (contingent negative variation). CNV appears as a slow cognitive potential with a component of negative polarity. It appears before the critical stimulus in the oddball paradigm (expectation) and immediately after it (initiation of decision-making). It thus arises as a preparation for motor response to a stimulus and may remain as a product of the mental process in the form of imagining this motor response. The CNV has a maximum amplitude in the central part of the CNS.

The onset of bioelectric voltage change in the neuronal networks evoked by the oddball tasks, i.e. the manifestations of cognitive evoked potentials (ERP) such as CNV (contingent negative variation), P300 wave etc., also give evidence of the dynamics of neuronal activity. In the time between the critical signal and the onset of the P300 wave, slow brain potentials can be observed in the beginning which are associated with the spreading of information through the structures of the brain which contribute to the solution of a task (amplitude is expressed in microvolts, latency and duration in milliseconds). The duration or the negative or positive component with the given latency between the critical signal and the appearance of the P300 wave are affected by the

degree of psychological tension, stress level, attention oscillations and dispositional risk characteristics, especially in the area of emotionality, which can be analysed using psychodiagnostic methods. The evaluated parameters are the presence or absence of activity of the adequate cortical zones, polarity (negative, positive), amplitude and frequency (from the basic to the target), the duration of the microstate (sections of temporally stable topography), reaction time from the critical signal of the oddball task to the appearance of ERP, in this case in the form of a P300 wave.

During our research activities, we have, inter alia, analysed the course of the P300 wave using visual stimulation in the oddball paradigm (see Sams, Alho et al., 1983). The configuration of the P300 wave differs from waves directly linked to a stimulus. Two visual stimuli are presented: a standard stimulus and a critical (target) stimulus at a ratio of 5:1. In the EEG recording, a positive ERP component dominates among the cognitive evoked potentials (their average value) with a latency of 400–550 ms, i.e. a P300 wave with a response maximum in the centro-parietal area. The P300 is essentially a result of deliberate human intervention into the events of the process of decision-making when solving problems or initiating answers. That means that a number of mental functions is activated and integrated. The activity has been decided upon above all by the initiator of the decision, i.e. the self (core) of the person. Motive, deliberate attention, cognitive processes, volitional process, emotionality etc. interact with each other here. The key role in the ultimate decision is played by the self. Executive functions also contribute to the result of the cognitive solution to a task. The biological marker of checking the correctness of the implemented solution is a minor negativity (CRN/Nc) whose amplitude is significantly higher in the case of incorrect implementation of the response to the critical signal (ERN/Ne).

The existing research also shows that positive emotions have an activating effect especially on the left prefrontal zone and the central zone and enhance the positive components of ERP. Negative emotions, mental tension, high stress level, depression, aggression, anger etc. have an activating effect especially on the medial and right-side posterior brain structures and intensify the negative components of ERP. When using a visual stimulus, negative components of ERP will appear, such as CNV – slow cognitive potential with negative polarity, N2a (MMN) with a latency of ca 300 ms, located temporal-occipitally or N2b with a latency of ca 350 ms with a maximum amplitude in postero-central position. These waves are generated mainly from dorsolateral prefrontal cortex, parietal and temporal cortex and gyrus cinguli and appear during unconscious processing of sensory stimuli without deliberate attention or the intervention of the self. Their occurrence and frequencies do not correlate with the cognitive solution of the problem. If the frequency of the occurrence of negative ERP components, latency, reaction time or maximum negative voltage exceed the physiological limits, pathology might be a reasonable conclusion. In these cases, it is possible to diagnose attention concentration disorders with intense negative emotions, indecision or even inability to initiate activity and high stress level with low level of frustration tolerance. Even deviations from the physiological course of the P300 can signal severe pathology, such as the onset of Alzheimer's dementia, Parkinson syndrome etc.

For the analysis of psychological markers, we used the classic psychodiagnostic methods which are, at the same time, indicators of dispositional differences or even abnormalities in the psychological phenomena studied and in the neuron complexity of the

associated portions of the neural network. Using psychodiagnostic methods, we analysed the differences between people exhibiting health-enhancing behaviour and people exhibiting health-threatening behaviour in the aspects of depressivness (DDF, Steck, 2008), degree of anxiety (STAI X-I, STAI X-II; Spielberger, 1989), degree of neuroticism (EPQ, Eysenck, & Eysenck, 1975) and impulsiveness (IVE, Eysenck, & Eysenck, 1978), values determined by the Cloninger questionnaire (TCI-R, Cloninger et al., 1994a) and the SSSI questionnaire (Zuckerman, 1964). (Results – rough scores – see appendix.) We are interested in the relationships between EEG rhythms and the detected dispositional negative psychological phenomena diagnosed using the above listed psychodiagnostic methods. We are also focusing on the relationships between EEG rhythms and the present psychological difficulties detected by these selected psychodiagnostic methods in both groups of probands. In this case, we are dealing with functional mental disorders evoked by adverse conditions in various stages of the life of the people included in the research.

Results

What we have stated in the above paragraphs will now be backed by the results of the examination of two people: one representative (code number 35) of the group of probands exhibiting health-threatening behaviour, and one representative (code number 46) of the group of probands (totalling 15 people) who exhibit health-enhancing behaviour. Since examination has not yet been completed for all 30 probands, broader interpretation is not possible.

Figures 1/35 and 2/46 present EEG microstates (Lehmann, (2009)) and relatively stable EEG topography (brain maps), i.e. global neuronal activity of the working constellations of neurons in neuronal networks without stimuli, decisions or conscious cognitive processing of information. This topic has been explored in more detail for example by Bressler (1995), Baars (1997) and others. (Topography is fixed, but polarity may be reversed.) It is a global brain activity characterised by the relative independence on the frequency on which tought operations not related to stimuli are generated (unconscious cognitive activity). This mental activity, independent of stimuli, is not identical to DMN, which has a different function. However, it is important for maintaining the stability of neuronal networks, as well as for their flexibility. Thus, we are dealing with rapid changes in the configurations of working neuron constellations depending on the requirements of specific cognitive processes, during conscious cognitive activity focused on conscious resolution of a problem initiated by current stimuli (Britz, 2009; Koenig, 2002 and others). EEG microstates provide evidence of sequenced neurophysiological activity, which then paradoxically "carries" the continuous mental activity. This, however, is an extremely important instant since everything that takes place at a material level in 3D space must respect its laws and time. In contrast, a thought is independent in this respect, and the self can decide in a split second on a change of direction in activities by 180°. Therefore, neuronal networks must have enough time to establish a sharp boundary and change in their structure. The altered configuration of the working constellations of neurons then allows the realisation of the changed objective. Example: Let us consider a certain time period. In this time period, we shall cognitively process a problem consisting of a number of types of visual information (words, indexes, icons etc.). The basis of mental

activity is that thought operations currently create operational structures from specific thought operations which can always operate with exactly the type of information which is currently available. The resulting product interacts with a certain type of memory and is simultaneously immanently integrated within this type. This happens with the cooperation of other psychological processes associated with the current conscious mental activity. However, everything can change in a split second on the basis of immediately effective stimuli. Therefore, the neuronal network must plastically react and restructure the relevant working constellations of neurons so that they can always provide the currently updated interacting mental functions, allowing one, through their processual aspect, to reach the altered goal in accordance with the decision made by the self.

The issue is that EEG microstates affect perception and cognition, which may be linked with the qualitative side of mental activity when creating mental operational structures for working with the specific type of information or degree of emotional instability, level of stress, mental tension, disharmony in the structure of personality etc.

We have mentioned that neuronal networks must ensure stability of networks as well as their flexibility and rapid restructuring of working constellations of neurons based on the currently effective stimuli. However, the self determines, due to preference of motives, intentions and goals of an activity, how spatial formulae of the working constellations of neurons in neuronal networks will be organised. We expect that research in this very area will gradually lead us closer to the understanding of connectivity between neurophysiological and psychological phenomena and the path to better understanding the essence of the human psyche.

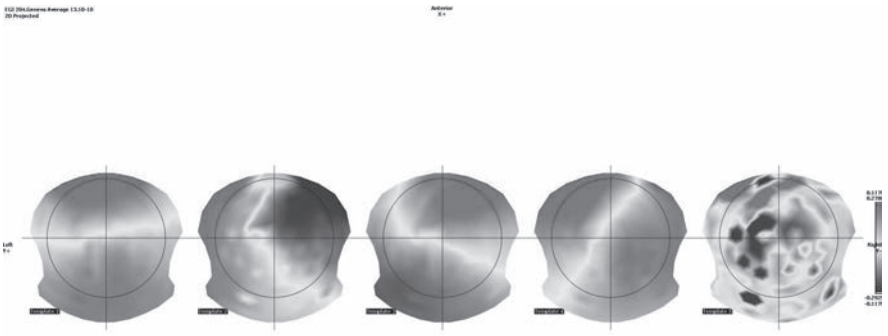
In our research, we have analysed EEG microstates in a course of 5 minutes, meaning 300 thousand EEG microstates. Using cluster analysis, we obtained 5 brain maps in proband no. 35 and 6 mental maps in proband no. 46. Each brain map represents a total of the most commonly recurring microstates from a total number of 300 thousand microstates over 5 minutes. We will highlight the differences in EEG topography in the following paragraphs.

Proband no. 35 is a man working as a bricklayer. He comes from a complete family. He is long married and has two children. Since childhood, he has had problems due to minor case of dyslexia and dysgraphia which have, to an extent, influenced his future lifestyle. He often had to cope with ridicule from his peers before he won them over with "antics". He also had to deal with frequent criticism from his parents and teachers, who placed greater demands on him than he could meet given the circumstances. These "circumstances" are important, since in his case, the issue did not lie in his potential, but the disproportionate demands regarding the fulfilment of tasks, considering his condition. Since he was rarely accepted the way he truly is, this lead to a formulation of a role-self. As is clear from table 1/35 in the appendix, he makes effort for others to pay attention to him, expressively promotes himself, is excessively confident and unconventional or friendly in cases where he needs to gain something, which attracts some people, especially women. In reality, his true self is experiencing the opposite of what we described. He does not trust people much, realises that he has been treated poorly and often doubts the good intentions of other people. He sometimes manipulates them to, in his own view, avoid manipulation on their side. His life is also complicated by an anancastic element in the structure of his personality. He has a tendency towards pedantry and precision. When he is unsuccessful, he reacts impulsively, is stubborn and unwilling

to make changes. If he has to meet a number of deadlines, he is prevented from pursuing the excessive need for orderliness. If being monitored, he makes enormous effort to "put his best foot forward", despite his own disagreement with the insistence of others that he keep promises. From a certain perspective, it can be said that he is a diligent and assiduous person, who does not always succeed in achieving the set goal due to the way his psyche is set up (whether due to his dispositions or the effects of his upbringing and environment). To appear better in order to be more accepted by others is to surrender some aspects of himself and be what others want him to be in some respects. It is a strong motif in the life of this person. To feel better, he solves the situation by repeatedly establishing short-term relationships with women and frequently drinking alcohol. He does not respect a healthy lifestyle.

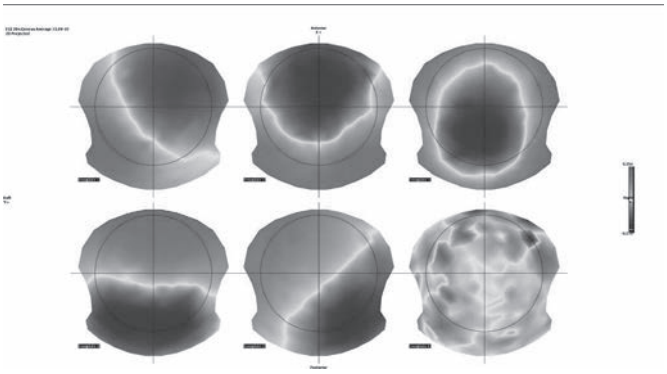
These contradictions between the inner and the outer, however, evoke anxiety, mental tension and constant checking of what he has just done. Thus, he again and again convinces himself that what he has done was not done well enough, that it was "wrong". This has significantly manifested in his work with the diagnostic methods. A high lie score, for instance, made it impossible to interpret the results of the TCI – R questionnaire. However, our research emphasised only how the listed psychological characteristics manifested in the EEG topography. I.e. our focus was the level of connectivity between the neurophysiological and psychological phenomena present in this man's case.

Fig. 1/35 displays 5 maps. The column labelled Num TF is the number of microstates which took place on each of the maps over the course of five minutes from a total of three hundred thousand possible microstates. If we compare these five maps, it is possible to analyse even from the perspective of the time parameter that the polarity of EEG



Subject	Map	NumTF	MeanCorr	Gev	BCorr	MaxGfp	MeanGfp	TimeCov
35	Map1	27451	0.619995	0.241391	0.985726	12.449792	1.202946	0.244007
	Map2	25276	0.570516	0.076584	0.982826	6.131217	0.925273	0.224674
	Map3	28987	0.570906	0.101941	0.984816	8.847343	0.930088	0.257660
	Map4	23419	0.562396	0.063286	0.990096	6.111072	0.891506	0.208167
	Map5	7368	0.505814	0.033055	0.982238	14.301604	1.120128	0.065493

Figure 1/35:
Outcome of cluster analysis: brain maps of proband 35



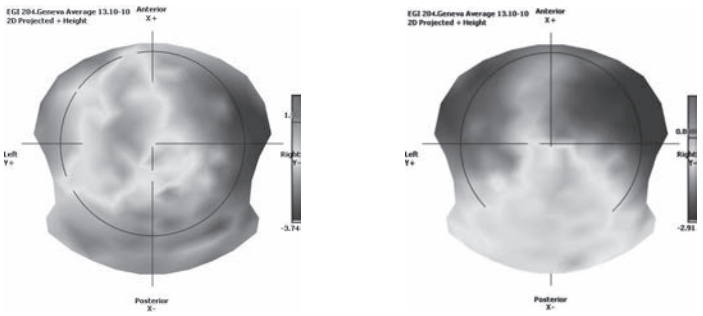
Subject	Map	NumTF	MeanCorr	Gev	BCorr	MaxGfp	MeanGfp	TimeCov
46	Map1	18947	0.586058	0.076182	0.984869	4.044893	0.956384	0.168416
	Map2	29434	0.648148	0.173460	0.987318	3.938360	1.036516	0.261633
	Map3	17034	0.534050	0.045852	0.970588	3.393322	0.888472	0.151412
	Map4	27568	0.645106	0.163006	0.990825	3.840397	1.041675	0.245047
	Map5	13367	0.559775	0.043305	0.980213	6.785229	0.907555	0.118817
	Map6	6151	0.639992	0.050781	0.982581	4.982811	1.282582	0.054675

Figure 2/46:
Outcome of cluster analysis: brain maps of proband 46

topography changed since the beginning. It is obvious that in this first step, where the proband did not have to solve any problems, he was in a resting state. That means he was looking forward to the task, he wanted to "do a good job". The positive emotions activate mainly the left prefrontal zone and in the direction of the centro-parietal area and intensify positive polarity (see the red colour). However, due to the mental setting of the proband which we have described in the previous paragraphs, it is certain that mental tension was growing within and anxious reactions and anger at oneself started to manifest. This state, negative emotions, started to actively interfere with the medial and posterior right-side structures, including gyrus cinguli and intensified negative polarity (see the blue field). At the same time, the proband was trying via self-control to reach a desirable state, as shown by the changes in polarity in the EEG topography. His conscious effort lead to the disruption of the neuronal dynamic and the dissolution of continuous fields signalling chaos and possible impulsive reaction (see brain map no. 5).

In proband no. 46, we obtained 6 brain maps from the same task. The column labelled Num TF is again the number of microstates which took place on each of the maps over the course of five minutes from a total of three hundred thousand possible microstates (see Fig. 2/46). The subject is a single, university-educated man, aged 37, who works as a university professor and lives with a partner and her children in the same household. As is clear from the table in appendix 2/46, some constituent characteristics are similar to those of proband no. 35. This concerns mainly the anancastic element which, however, the proband "works with" differently than proband no. 35. The overriding focus of his temperament to an extent also frames his ultimate behaviour. His education and

FREQUENT **TARGET**



Electrode	Magnitude of Frequent stimulus	Magnitude of Target stimulus
F2	-1.1326	-1.8780
FCz	0.0969	-0.8756
FC1	1.2592	-0.5669
F1	1.2749	-0.4671
C1	1.9300	-0.1252
P1	0.7212	-0.0762
CPz	0.1551	0.4016
O1	-1.1484	0.2948
Oz	-1.0561	0.5155
P2	-0.2864	0.4566
O2	-1.2544	0.5706
C2	0.0146	-0.8972
FC2	-0.8338	-1.8706

Figure 3/35:
Frequent and target brain map; time delay -1ms

employment are evidence of potent general intellectual ability, which allows him to make quick decisions and offers a wider spectrum of variants of solving problematic situations. This is sometimes at odds with his predominantly phlegmatic temperament and rather introverted self-experience, since rapid generation of precise rational solutions to problems in the mind is not realised quickly enough on the behavioural level. This is also linked to a tendency to postpone tasks and deadlines on one side and excessive precision, systematic nature and orderliness in everyday life on the other. Postponing tasks does not stem from laziness in this person, but from lower activation level. He thus requires a stronger impulse not to increase adrenaline levels but to start creative work activity. Once he decides and begins work, however, he is very creative and persistent. He sees difficult tasks as a challenge. Such an arrangement of the intrapsychological

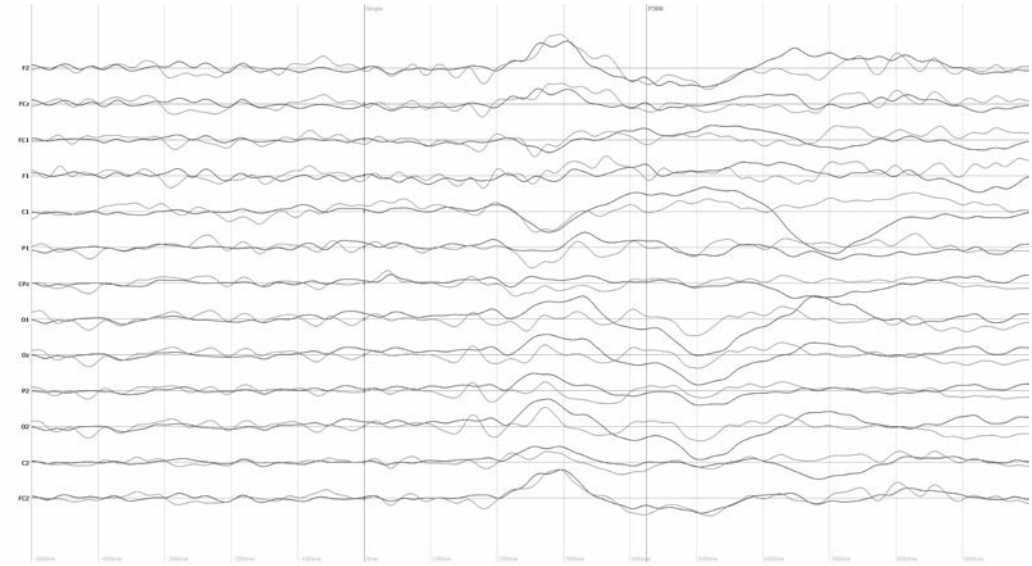
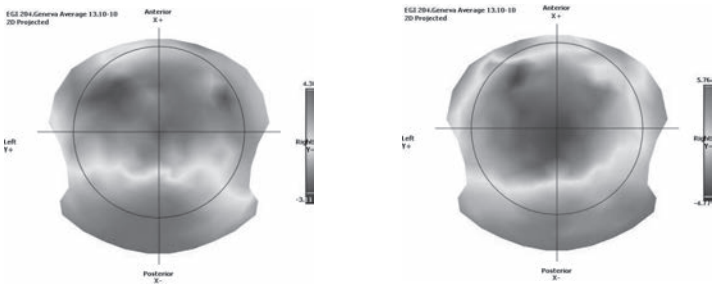


Figure 4/35:
Electroencephalogram of proband 35

space leads to inner tension, slight emotional lability and light mental stress. As an individualist, proband no. 46 is rather reserved in contact with strangers. He is sensitive and perceptive in relationships but he keeps his energy in reserve during emotional experience. He shows a degree of shyness.

What we have said of proband no. 46 so far we shall now compare with his EEG topography in resting state. When comparing the maps on Fig. 2/46, we find that the proband was willing and ready to complete tasks, but had to make effort to maintain self-control in the unknown environment with an indeterminate task at hand and strangers around. When comparing maps 1 and 2, it is evident that the positive anticipation of the events to come intensified the positive polarity and right-hand structures, including the insular cortex. However, since the anticipation did not yield any action demanded by the doctor, which the proband was ready for, negative polarity strengthened centro-parietally, signalling increasing tension in the proband (see map 3). The proband increased the degree of self-control and the subsequent calm brought him to the decision to "let things unfold" (see map 4 and 5). The increased energy consumption, however, led to a loss of attention concentration and to absent-mindedness and fractional oscillation of polarities (see map 6). Looking over the six brain maps, we can state that the proband was ready and willing to participate in the research, but despite the already stimulated cognition, an adequate task was not set before it to work with. This led to discomfort, resulting in slight mental tension, which intensified the negative polarity in EEG topography. Simply put, when already stimulated, the proband requires that the given work activity immediately take place, not be further postponed.

FREQUENT **TARGET**



Electrode	Magnitude of Frequent stimulus	Magnitude of Target stimulus
F2	-1.8241	-1.4978
FCz	-2.2671	-2.5899
FC1	-2.2167	-3.3830
F1	-1.9815	-2.7923
C1	-1.7222	-3.8140
P1	-0.6545	-3.3385
CPz	-1.5127	-4.1159
O1	-3.3155	2.9333
Oz	3.2698	2.6708
P2	-0.0964	-1.7094
O2	2.8713	2.9806
C2	-2.2307	-3.2221
FC2	-2.1390	-2.7627

Figure 5/46:
Frequent and target brain map; time delay -8ms

In the following steps of our research, we focused on the study of cognitive evoked potentials (ERP) which, we assume, are suitable for the study of the connectivity between neurophysiological and psychological phenomena. Thus, in the second part of the examination, the probands 35 and 46 were tasked with reacting to a target stimulus in the oddball paradigm. First, we will focus on proband no. 35 (see Figure 3/35 and Figure 4/35).

The left brain map in Figure 3/35 signals mental tension and the desire to present oneself well. The map to the right bears evidence of the fact that the proband detected the target stimulus, but the tension whether he is reacting properly has affected his decision (he remained in the set-up for solving a problem even when the P300 wave had passed; in his eyes: "perhaps I solved it, but certainly the wrong way"). This cor-

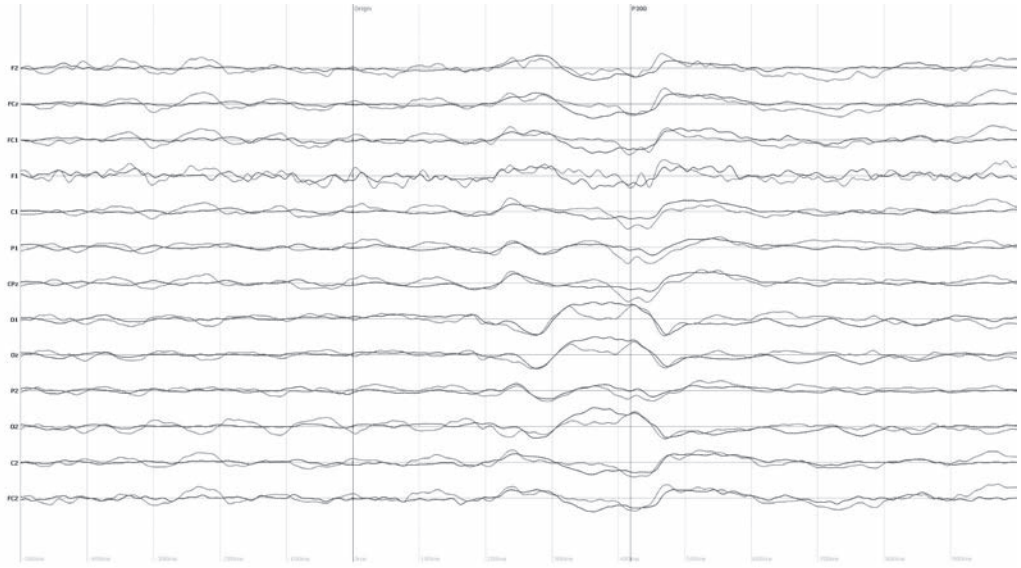


Figure 6/46:
Electroencephalogram of proband 46

responds also to the recording shown in Figure 4/35. The P300 wave occurred with normal latency, as a positive ERP component partially in the centro-parietal zone, but with pronounced negative ERP components surrounding it. The amplification of the negative ERP components is intensified by negative emotions, high stress level, mental tension, anger etc.

The neuronal activity in proband no. 46 is shown in Figures 5/46 and 6/46. The brain map in Figure 5/46 on the left shows the readiness of the structures to react to visual target stimulus, good attention concentration, but also a certain degree of mental tension (see CNV in Figure 6/46 – pronounced negative ERP component before the target stimulus, which we did not expect in this proband; the results of the psychodiagnostic examination also did not indicate this result). The P300 wave occurred with latency within the norm. Figure 6/46 tells us that the return to the feeling of good cognitive performance after the occurrence of the P300 wave is confirmed by low negativity (CRN/Nc). We assume that it is typical for this person to experience a certain degree of mental tension whenever he is to initiate cognitive activity, as if he was not sure he will be able to mobilise sufficiently for such an activity. However, if cognition starts, the cognitive activity itself assures him with the knowledge that "he is on it".

Discussion

In subsequent research, which shall follow up on the probe discussed here into a first research project we want to make use of the data obtained via cluster analysis of EEG

topography, which has revealed the so-called EEG microstates. We wish to relate these microstates (maps) to hemodynamic BOLD signal detected by fMRI. Our design partially builds on the work of D. Lehmann et al. (2009, J. Britz et al. (2010) a R. Mareček et al. (2012). We want to determine how it is possible, that despite the time offset between rapid bioelectric activity (EEG waves) and slow hemodynamic BOLD signal, there is no disruption in the dynamics of complex mental activity. Why is it that we do not function sequentially? The higher the P300 wave, the higher change in the BOLD signal that accompanies it.

fMRI is capable of mapping dynamic changes in neuronal activity, caused by local fluctuations of oxyhaemoglobin and deoxyhaemoglobin (BOLD = Blood Oxygenation Level Dependent). fMRI has a high differentiation capability (in the order of mm), but low temporal resolution. BOLD is based on the fact that active areas which consume more O_2 send out a stronger signal than the less active surroundings. BOLD allows the location of the source of these signals. We wish to determine how the postsynaptic activity transforms into an EEG signal and BOLD signal and what internal and external factors affect this transformation. We are also interested in studying the relationship between the BOLD signal and EEG topography.

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Annex 1. Psychodiagnostic outcome

Proband n. 35 – male, 56 years old, employment: bricklayer

DDF- Depresivity differential questionnaire (Steck, 2008)

Scale	Rough score	T-core	Percentil	Conf.interval ($p < 0,05$)
Fobic	6	42	22	35–49
Somatized	5	46	34	41–51
Hypochondric	4	47	36	40–54
Self-torment	7	48	42	42–54
Paranoid	9	55	70	48–62
Anankastic	8	53	60	44–62

STAI- Stait- Trait Anxiety Inventory (Spielberger, 1989)

Inventory	Rough score	Sten: Gender	Percentil
Stait anxiety	42	6	65
Trait anxiety	48	7	75

EPQ-R- Eysenck's personality questionnaire revised (Eysenck & Eysenck, 1975)

Scale	Rough score	m for male aged 51–60	sd
Psychoticism	3	2,28	1,61
Extraversion	11	4,48	3,69
Neuroticism	7	4,49	3,70
L-score	2	5,16	2,8

IVE- Eysenck's impulsivity inventory (Eysenck & Eysenck, 1978)

Scale	Rough score	m for male aged 50–59	sd
Impulsivity	11	5,38	4,14
Venturesomeness	3	6,16	3,40
Empathy	10	12,05	3,14

Sensation Seeking Scale (Zuckermann, 1964)

Scale	Rough score (max. 40)
Sensation Seeking	16
Boredom Susceptibility	4
Disinhibition	5
Experience Seeking	5
Thrill and Adventure Seeking	2

TCI-R- Temperament and Character Inventory (Cloninger et al., 1994a)

Scale	Rough score	m for male	sd
Harm Avoidance	91,08	94,71	15,82
HA1:Anticipatory worry	32,01	30,73	5,63
HA2:Fear of uncertain	20,02	21,95	4,76
HA3: Shyness with strangers	20,02	20,63	5,13
HA4: Fatigability	19,04	21,40	4,37
Novelty seeking	98	102,33	14,75
NS1:Exploratory excitability	28	30,16	5,33
NS2: Impulsiveness	24,03	25,06	4,13
NS3: Extravagance	25,02	26,77	6,81
NS4: Disorderliness	21	20,34	3,57
Reward Dependence	96,9	97,23	13,23
RD1: Sentimentality	32	26,51	3,98
RD2: Open to warm communication	34	32,61	6,45
RD3: Attachment	16,98	18,63	4,31
RD4: Dependence	13,98	19,48	3,09
Persistence	134,05	109,36	15,75
PS1: Eagerness of effort	36	27,02	4,69
PS2: Work hardened	34	26,46	4,42
PS3: Ambitious	38	31,28	5,67
PS4: Perfectionist	26	24,6	4,43
Self-directedness	121,2	136,58	14,04
SD1: Responsibility	25,04	29,35	3,89
SD2: Purposefullness	22,02	21,6	3,91
SD3: Resourcefulness	14	17,3	2,64
SD4: Self-acceptance	28	30,93	6,13

Scale	Rough score	m for male	sd
SD5: Congruent second nature	32,01	37,41	4,97
Cooperativness	114,12	125,15	14,03
CO1: Social acceptance	29,04	28,59	3,50
CO2: Empathy	15	17,04	2,82
CO3: Helpfulness	28	28,32	3,69
CO4: Compassion	20,02	23,45	4,86
CO5: Principled	22	27,76	3,90
Self-transcendence	81,12	68,46	13,65
ST1: Self-forgetfulness	38	28,87	6,20
ST2: Transpers. identification	30	19,87	5,24
ST3: Spiritual acceptance	13,04	19,72	5,72

Annex 2: Psychodiagnostic outcome

Proband n. 46- male, 36 years old, university professor

DDF- Depresivity differential questionnaire (Steck, 2008)

Scale	Rough score	T-score	Percentil	Conf.interval ($p < 0,05$)
Fobic	1	33	4	26–40
Somatized	1	38	12	33–43
Hypochondric	0	34	5	27–41
Self-torment	1	36	8	30–42
Paranoid	0	35	6	28–42
Anankastic	12	64	92	55–73

STAI- Stait- Trait Anxiety Inventory (Spielberger, 1989)

Inventory	Rough score	Sten: Gender	Percentil
Stait anxiety	40	6	55
Trait anxiety	42	5	50

EPQ-R- Eysenck's personality questionnaire revised (Eysenck & Eysenck, 1975)

Scale	Rough score	m for male aged 51–60	sd
Psychoticism	4	2,82	1,84
Extraversion	1	6,40	3,85
Neuroticism	1	5,75	3,46
L-score	0	3,58	2,2

IVE- Eysenck's impulsivity inventory (Eysenck & Eysenck, 1978)

Scale	Rough score	m for male aged 50–59	sd
Impulsivity	3	7,06	4,20
Venturesomeness	11	7,25	3,70
Empathy	8	11,87	3,36

SSS- Sensation Seeking Scale (Zuckermann, 1964)

Scale	Rough score (max. 40)
Sensation seeking	21
Boredom Susceptibility	5
Disinhibition	3
Experience Seeking	5
Thrill and Adventure Seeking	8

TCI-R- Temperament and Character Inventory (Cloninger et al., 1994a)

Scale	Rough score	m for male	sd
Harm Avoidance	102,96	94,71	15,82
HA1:Anticipatory worry	33,99	30,73	5,63
HA2:Fear of uncertain	24,01	21,95	4,76
HA3: Shyness with strangers	25,97	20,63	5,13
HA4: Fatigability	19,04	21,40	4,37
Novelty seeking	84	102,33	14,75
NS1:Exploratory excitability	22	30,16	5,33
NS2: Impulsiveness	21,96	25,06	4,13

Scale	Rough score	m for male	sd
NS3: Extravagance	18	26,77	6,81
NS4: Disorderliness	21,98	20,34	3,57
Reward Dependence	78	97,23	13,23
RD1: Sentimentality	22	26,51	3,98
RD2: Open to warm communication	20	32,61	6,45
RD3: Attachment	15	18,63	4,31
RD4: Dependence	21	19,48	3,09
Persistence	91	109,36	15,75
PS1: Eagerness of effort	19,98	27,02	4,69
PS2: Work hardened	22	26,46	4,42
PS3: Ambitious	26	31,28	5,67
PS4: Perfectionist	23,04	24,6	4,43
Self-directedness	133,2	136,58	14,04
SD1: Responsibility	30	29,35	3,89
SD2: Purposefullness	21	21,6	3,91
SD3: Resourcefulness	13	17,3	2,64
SD4: Self-acceptance	27	30,93	6,13
SD5: Congruent second nature	42,02	37,41	4,97
Cooperativness	110,16	125,15	14,03
CO1: Social acceptance	18	28,59	3,50
CO2: Empathy	12	17,04	2,82
CO3: Helpfulness	27,04	28,32	3,69
CO4: Compassion	21	23,45	4,86
CO5: Principled	32	27,76	3,90
Self-transcendence	43,94	68,46	13,65
ST1: Self-forgetfulness	20	28,87	6,20
ST2: Transpers. identification	11,04	19,87	5,24
ST3: Spiritual acceptance	13,04	19,72	5,72