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ASSURANCE OF EFFECTIVE FOLLOW-UP OF PROLONGED COSTLY TASK CONTRACTS USING BIOMEDICAL METHODS

Abstract: The aim of the present project is to: determine the level of influence of neurofeedback sessions on the phenomena of the stress model experienced during isolation according to molecular, biochemical, neurophysiological and psychomotor signatures. We believe that according to selected stressors, the result will be similar and that neurofeedback sessions will reduce the level of stress in various areas and stabilise the motivation to perform difficult tasks over a longer period of time. Against this background, the authors will identify and deconstruct the existing legal, psychological and biological conditions of human work under a high stressor – isolation, that can be found in three basic areas that the authors intend to study: offshore oil rigs, polar stations and space missions. Finally, the authors aim at designing an optimal standard form contract, supplemented with collected results of a designed set of biomedical tests performed at the pre-contractual stage, as well as measures to influence the human stress response at the contract implementation stage, which would reduce the uncertainty and thus the risk for any of the parties to such a contract, as well as any third parties that might be affected by human mistake in effectuating high-risk high performance contracts.

Keywords: high-risk high performance contracts, work under stress, isolation, astronauts, polar scientists, oil-rig workers, neurofeedback, biomedical methods & the law, safety culture, informed consent

1. PROPOSAL ABSTRACT

Aim 1. Defining the level of influence of neurofeedback sessions on stress model profiles experienced during isolation according to molecular, biochemical, neurophysiological, psychomotorical signatures.

Aim 2. To identify and deconstruct the existing legal, psychological and biological conditions of human labour performed under high levels of stressors: eg. isolation, sleep-deprivation, psychological pressure resulting from multitasking and team work, in an environment aggressive for the human body, displaying properties such as: extreme temperatures and pressure, very high or low humidity, polar night/day, magnetic storms etc. Such conditions can be identified in three basic fields the authors are intending to scrutinize: offshore oil-rigs, polar stations and space missions.

Aim 3. To design an optimal standard form contract supplemented by a set of biomedical tests done at the pre-contractual stage, as well as means of influence on human stress-reaction at the stage of contract performance, that would reduce uncertainty and thus risk inevitably placed on either party to such a contract¹. In this context, greater attention should be paid to obtaining informed consent from those involved in such activities. The contemporary doctrine of informed consent does not provide further guidance in this regard, other than indicating that the provisions will define the final scope of this institution. However, a problem arises from the domestic perspective: "Is the question....?" Is the doctrine of "informed consent" in the context of isolation meant to be synonymous with "informed consent" in the context of Polish medical law? If so, then these opposing legal liability regimes may be incompatible in goals and purpose. The logical consequence of such a situation would be to redefine the regime of informed consent for purposes such as high-risk missions that fell categorically outside the context of medical law. We suggest a rights-based approach, referred to in the literature as "informed decision making", signifying the process through which astronauts make individual decisions to participate in specific long duration activities².

Subject: A case control approach will be followed comprising of healthy male and female participants: 50f + 50m for the experiment group and 50f + 50m for control group.

Methods: The following methods will be used: genes expression changes connected with stress reaction of human cells (e.g. *IL6*, *IL6R*, *IL1B*, *CYBA*, *CYBB*, *TNFA*, *CCL2*, *CCL3*, *CCL5*, *CCR2*, *CCR3*, *CCR4*) expression changes of genes recognized as associated with human psychological abilities (e.g. *DRD2*, *DRD3*,

¹ T. Wilhelmson 'Standard form conditions' [in:] A. Hartkamp, M. Hesselink, E. Hondius, C. Joustra, E. du Perron and M. Veldman (eds) *Towards a European Civil Code* (Ars Aequi Libri, Kluwer Law International Nijmegen 2004); G. G. Triantis, *Unforeseen Contingencies. Risk Allocation in Contracts* in B Bouckaert and G de Geest (eds) *Encyclopaedia of Law and Economics* (Edward Elgar Publishing and the University of Gent 1999); G. de Geest 'Comparative Law and Economics and the Design of Optimal Legal Doctrines' (2001) 6 *Law and Economics in Civil Law Countries*.

² R.R. Faden, T.L. Beauchamp, *A history and theory of informed consent*. New York: Oxford University Press; 1986.; J. Emanuel, D. Wendler, C. Grady, What makes clinical research ethical. *JAMA*. 2000; 311(9), pp. 2701-2711.

DRD4, DAT1, DBH, COMT, TPH2, ANKK1, MAOA, CHRNA4) or in case of difficulties of blood sampling miRNA profiling of saliva samples will be conducted; Vienna Test System: eye – hand, stress tolerance, attention, memory with sEMG (m. rectus abdominis, m. trapezius), which allows precisely to record the duration of latent voluntary contraction and relaxation, can be used for assessment of the intensity of central commands that control muscle contraction; questionnaires: KPS (stress feel), UMACL (mood) *Plopa, Markowski*, Neo-PI-R (personality), PERMA (well-being), PERMA – Kern; EEG brainwaves signals evaluation (alpha, beta, gamma, theta, and delta), which reflects the mental state of subjects.

Experiment: Defining the base level – measurement no. 1 of each stress signatures before the stressor (isolation) will be engaged. Creating two groups: experiment and control. All subjects will be exposed for isolation (up to 12 months). After a few months we will take measurement no. 2 to find out the differences between the base line and the line after the isolation. Neurofeedback session (the ability of EEG self regulation shaping, each subject independently regulates mental states responsible for the EEG record) will be implemented to the experiment group. After the isolation both groups will participate in the measurement. Based on results stemming from biomedical methods, legal issues will be addressed. The legal sciences project specialists will work to identify and deconstruct the existing legal – related to psychological and biological – conditions of human labour performed under high levels of stressors: eg. isolation, sleep-deprivation, psychological pressure resulting from multitasking and team work, in an environment aggressive for the human body, displaying properties such as: extreme temperatures and pressure, very high or low humidity, polar night/day, magnetic storms etc. Such conditions can be identified in three basic fields the authors are intending to scrutinize: off-shore oil rigs, polar stations and space missions. Based on comparative analysis of law and its practice, which inadequately addresses the identified problem, taking also the law and economics approach focused on efficiency, optimal standard form contracts shall be designed. They will be supplemented by printed results of a set of biomedical tests done at the pre-contractual stage, as well as means of influence on human stress reaction at the stage of contract performance, that would reduce uncertainty and thus risk inevitably placed on either party to such a contract. Consequently, all parties to the contract will be significantly relieved of those uncertainties and given the necessary insurance – premiums will need to be calculated after taking these factors into account, thus, as we expect, they will be considerably lower.

2. EXPERIMENT SCIENTIFIC OVERVIEW

2.1. SCIENTIFIC BACKGROUND

PROPER EXECUTION OF HIGH-RISK HIGH PERFORMANCE CONTRACTS

Proper performance of contracts (be it long-term – as in space missions, or short-term, but requiring unusual flexibility and perseverance, which could be reflected upon as the modern-day precarity, even if well-paid)³ is of utmost importance within the three fields of application covered by the study. An anthropological perspective offered by Filipe Cálvao does not seem exaggerated or unfit even in this context: "cases of enslavement are often presented as symptomatic aberrations that produce a pretense of normalcy in a time of uncertain futures"⁴. Such might occasionally be the sentiment of well-paid and highly-estimated astronauts reaching for the stars and enabling the giant leap for mankind with „one step"⁵, scientists discovering the mysteries and properties of Northern Lights on the North Pole, or oil-rig workers agreeing to – even if also superficially enjoying – constant demands for high flexibility⁶.

As regards labour agreements within this scope, certainty and pay-offs on both sides are highly desirable⁷, though not always present. Oil companies operate with very short standard forms – the worker's task is to tick the relevant box where the box has not yet been filled out by the employer, and sign 2 copies of the contract. Its full content is in fact mystery to the employee, who may not be skilled enough to read through hundreds of pages of contract codes, labour codes and collective agreements for the given sector of industry, often in a foreign language, let alone become acquainted with judicial interpretation thereof. On the other hand, the employer takes the risk of hiring a person unfit for the intended purpose of the contract. The case will be slightly improved with polar stations' staff and astronauts, as there are much less of them, and they usually had been highly qualified engineers, academics etc. that may be a little more informed and aware of risks inherent in the job they are tasked with, but the main problems resulting from highly stressful and unusual working conditions remain the same.

³ cf. H. Pristed Nielsen, *Offshore but on track? Hypermobile and hyperflexible working lives, Community, Work Family* 2016, 19:5, pp. 538-553, Remuss 2011, van Baarsen 2011

⁴ F. Calvão, *Unfree labour* [in:] *Annu. Rev. Anthropol.* 2016/45, pp. 451-67.

⁵ W. White, *Salvage Law for Outer Space* [in:] *Engineering, Construction and Operations in Space, Proceedings of the Third International Conference, Denver, Colorado 1992*, p. 2416.

⁶ H. Pristed Nielsen et al, *op. cit.*, pp. 546-548. I. Perry, P. Kfir, *Title IV of the U.S. Commercial Space Launch Competitiveness Act of 2015: A Critical Step Forward in Facilitating the Development of a Viable Space Infrastructure*, *New Space*, 1 Sept. 2017 r., vol. 5, no. 3, <https://doi.org/10.1089/space.2017.0008>

⁷ R. Cooter, T. Ulen, *Ekonomiczna analiza prawa*, CH Beck, Warszawa 2009, pp. 269-271.

LEGAL RISKS AND BIOMEDICAL METHODS OF LIMITING THEM

Risks arising from uncertainty as to the fitness for work in extreme conditions are present and real not only for the parties, but also for a number of stakeholders interested in proper performance of such exceptional labour contracts: O&G companies, research institutions, launching states or mission integrators – all being nowadays both government actors and private corporations⁸ – but also any other states, NGOs, trade unions, or regular citizens who may be severely affected by a human mistake resulting in grave consequences in tort but also infringement within the human rights protection system⁹. This is the case with oil platforms/installations explosions and gigantic oil-spills¹⁰ or spacecraft failures¹¹, which could be related to the human factor; perhaps less so with unfit polar stations' staff.

All the above stakeholders: the workers who invested time, money and lost opportunities (eg. family life) in their education and/or training; the employers, who invested in building the expertise and facilities necessary to carry out the prescribed highly demanding tasks, but – necessarily – also in the training and education of the crew members they fill those facilities with; and – though not at the center of our research but not to be neglected – any other potentially interested above mentioned third parties, including insurers, have different: more scientific and ecological, or more profit-oriented stakes¹². A level playing field could be

⁸ V. Kayser, *Private Involvement in Commercial Space Activities: Legal Issues and Recent Trends*, 37th Proc. L. Outer Space 1994, p. 315; A. Berman, *A pluralist Approach to International Law*, 32(2) Yale J. Int'l L. 2007, p. 316.

⁹ Including, but not limited to, environmental justice. See: Seibert-Fohr, *The Fight against Impunity under the International Covenant on Civil and Political Rights*, Max Planck Yearbook of United Nations Law 2002, no. 6, p. 306.

¹⁰ Cf. the case of Deepwater Horizon, in 2010, and Odebrecht NS-32, in 2017; M. Konopacka, *Metody i poziom zintegrowania prawa państw członkowskich UE w sferze ochrony środowiska morskiego* [in:] *Unia Europejska : zjednoczeni w różnorodności: konferencja*, Warszawa, 14-15 grudnia 2010 r., ed. Cezary Mik, Wydawnictwo Sejmowe, Warszawa 2012, p. 467-470; . E. M. França, E. Hollnagel, I.J.A. Luquetti dos Santos, N. Haddad, *FRAM AHP approach to analyze offshore oil well drilling and construction focused on human factors* [in:] *Cognition, Technology Work* (2020) 22:653–665 <https://doi.org/10.1007/s10111-019-00594-z>, Springer-Verlag London Ltd., part of Springer Nature 2019, p. 653; M. Abimbola, F. Khan, N. Khakzad, *Dynamic safety risk analysis of offshore drilling*. *J Loss Prev Process Ind Elsevier Ltd.* 30 (1) 2014 , <https://doi.org/10.1016/j.jlp.2014.05.002>, pp. 74-85.

¹¹ M. Konopacka, „State liability for outer space activities” [in:] *Per mare ad astra. Space technology, governance and law*, Gdansk 2019 (eds. E. Wittbrodt et al.), Polska Akademia Nauk 2019, pp.162-163, 167- 168, Ernest A., *The Liability Convention* [in:] *Workshop on Capacity Building in Space Law*, United Nation/International Institute of Air Space Law, The Hague 18-19 November 2002, p. 2.

¹² B. Lord, *On the Economic Use of Outer Space: A Clash of Values* [in:] *Air Space Law* 44, no. 2 (2019), p. 144; Kennedy D., *Law and the Political Economy of the World* [in:] *Critical Legal Perspectives on Global Governance: Liber Amicorum David M Trubek* 2013, edited by G. de Burca, C. Kilpatrick, J. Scott, pp. 88-89.

created with the use of state-of-the-art biomedical techniques, highly reliable and less fallible than the arcana of legal interpretation in case of a dispute, including Neurofeedback, and combining them with comparative legal analysis of

- a) contractual fairness¹³
- b) protection of workers¹⁴,
- c) liability for non-performance of contract¹⁵ and
- d) informed consent.

DESCRIPTIVE AND NORMATIVE APPROACH – DEVISING OPTIMAL LEGAL DOCTRINES

The above research shall be based on appropriate European and American rules originating in common contract principles – DCFR and ALI Restatement of Contracts supported by relevant case-law and coupled by labour law provisions, including collective agreements from selected jurisdictions most frequently referred to in our context, as assessed by the EFTA Court, the CJEU in Europe¹⁶ or federal and supreme courts in the US. In addition, relevant domestic, European and international standards and rules on informed consent shall be examined. It is the normative, not descriptive analysis that is at the center of our legal research plan. We submit that the law's unexpected and often unintended consequences¹⁷, resulting from non-performance or improper performance of the analysed types

¹³ P. Schlechtriem, *Good Faith in German Law and in International Uniform Laws* (Centro di studi e ricerche di diritto comparato e straniero, Saggi, Conferenze e Seminari, Roma 1997; Kötz H, *Towards a European Civil Code: The Duty of Good Faith in The Law of Obligations. Essays in Celebration of John Fleming*, ed. Peter Cane, Jane Stapleton, Clarendon Press, Oxford 1998; Konopacka M., *Dobra wiara w prawie umów* [in:] *Prawo prywatne w dobie przemian*, Wyd. UG, Gdańsk 2005.

¹⁴ M. Konopacka, *Deficyt solidarności, czyli status polskich pracowników delegowanych w RFN. Głosa do wyroku ETS z dnia 3 kwietnia 2008 r., C-346/06 Rüffert*, *Gdańskie Studia Prawnicze. Przegląd Orzecznictwa*. – 2014, nr 3, p. 89-102.

¹⁵ J. Gordley, *The Foreseeability Limitation on Liability in Contract* [in:] *Towards a European Civil Code*, ed. A. Hartkamp, M. Hesselink, E. Hondius, C. Joustra, E. du Perron, M. Veldman, *Ars Aequi Libri*, Kluwer Law International, Nijmegen 2004, pp. 215-228.

¹⁶ M. Konopacka, „Zasady Europejskiego Prawa Umów” [in:] „Ochrona praw jednostki”, seria „Acquis communautaire”, vol. 6, ed. Z. Brodecki, LexisNexis 2004.; O. Lando, *Non-Performance (Breach) of Contracts* [in:] *Towards a European Civil Code*, ed. A. Hartkamp, M. Hesselink, E. Hondius, C. Joustra, E. du Perron, M. Veldman, *Ars Aequi Libri*, Kluwer Law International, Nijmegen 2004, p. 506-510, M. Konopacka, *Deficyt solidarności, czyli status polskich pracowników delegowanych w RFN. Głosa do wyroku ETS z dnia 3 kwietnia 2008 r., C-346/06 Rüffert*, *Gdańskie Studia Prawnicze. Przegląd Orzecznictwa*. – 2014, nr 3, pp. 89-102.

¹⁷ C-W Canaris, H. Ch. Grigoleit, *Interpretation of Contracts* [in:] *Towards a European Civil Code*, ed. A. Hartkamp, M. Hesselink, E. Hondius, C. Joustra, E. du Perron, M. Veldman, *Ars Aequi Libri*, Kluwer Law International, Nijmegen 2004, p. 445 et. seq.; J. Stelmach, *Wokół pojęcia interpretacji prawniczej*, R. Sarkowicz, *Metody interpretacji tekstu prawnego* [in:] *Teoria prawa, Monografie Wydziału Prawa i Administracji Uniwersytetu Jagiellońskiego*, Wydawnictwo Uniwersytetu Jagiellońskiego, Kraków 1998, pp. 61-91.

of high-risk high performance contracts¹⁸, could be significantly mitigated, if not eliminated, with the use of extra-legal solutions. Ostrich-like tactics cannot prevent lawyers from admitting that the law and its practice are far too often vague and unpredictable, especially if being captured by non-democratic regimes or interest groups that forward profit-oriented goals.

In addition, globalisation makes the law a frequent object of misappropriation by conflicting interest-groups, next to traditional vulnerability to choice-of-law and jurisdiction more favorable to the stronger party¹⁹, forum shopping²⁰, lengthy court proceedings, or ADR: less time-consuming, better preserving trade secrets and reputation, but costly arbitration, or mediation – swifter and optimal, but requiring mutual concessions²¹. Scarce interdisciplinary studies already undertaken in a neighboring field focus on the interplay of management, technology and the failure of the human factor, applying FRAM AHP approach where the "lack of control of these processes, associated with the workplace, can cause potential losses, injuries to workers, and fatalities"²² or assessing the anthropological impact of „hypermobile and hyperflexible working lives on communities, work and family by interviewing local oil-rig workers and employers²³. Given the above and taking into account all legal problems and lacunae identified, there is urgent need for engagement into the proposed interdisciplinary experimental study and its immediate application.

THE DEMAND FOR GREATER CLARITY OF HIGH-RISK HIGH PERFORMANCE CONTRACTS

With respect to high-risk high performance contracts, it is utterly important to formulate the tasks in a clear and comprehensible manner. Interpretation problems may arise at any stage of the contract's existence: at the time of its

¹⁸ T. Wiśniewski [in:] *Komentarz do kodeksu cywilnego. Księga trzecia. Zobowiązania*, wyd. 6, ed. G. Bieniek, Wydawnictwo Prawnicze LexisNexis, Warszawa 2005, pp. 583-588., O. Lando, 'Salient Features of the Principles of European Contract Law: a Comparison with the UCC' (2001) 13 *Pace Int'l L Rev*; J. Gordley, *The Foreseeability Limitation on Liability in Contract* [in:] *Towards a European Civil Code*, ed. A. Hartkamp, M. Hesselink, E. Hondius, C. Joustra, E. du Perron, M. Veldman, *Ars Aequi Libri*, Kluwer Law International, Nijmegen 2004, p. 215-228.

¹⁹ M. Konopacka, *Dobra wiara w prawie umów* [in:] *Prawo prywatne w dobie przemian*, Wyd. UG, Gdańsk 2005.

²⁰ M. Konopacka, *Zasada ścisłego związku* [in:] *Europa Sędziów*, ed. Z. Brodecki, LexisNexis, Warszawa 2007.

²¹ M. Konopacka, *Mediation in closed circles: two examples*, *Kwartalnik PCM „Mediator”* nr 1/2015, pp. 15-35.

²² J. E. M. França, E. Hollnagel, I.J.A. Luquetti dos Santos, N. Haddad, *FRAM AHP approach to analyze offshore oil well drilling and construction focused on human factors* [in:] *Cognition, Technology Work* (2020) 22:653–665 <https://doi.org/10.1007/s10111-019-00594-z>, Springer-Verlag London Ltd., part of Springer Nature 2019, p. 653.

²³ H. Pristed Nielsen, *op.cit.*, pp. 538-553.

conclusion, performance, non-performance or improper performance. The expressions used to formulate the contract can sometimes be ambiguous, too vague, contradictory or unclear in the context of the entire content of the contract. Sometimes, in the absence of additional contractual provisions, it will be necessary to interpret this gap. Often, a given interpretation may lead to the conclusion that the contract has not been performed or is invalid. The question of interpretation is primary and logically separate from the question of the validity of the contract and the legal remedies available to the party.

It is necessary to precisely define the meaning of contractual clauses before it can be clearly stated that there has been a breach of certain provisions thereof, which would be the basis for the claim for damages or specific performance. It also happens that the very fact of concluding the contract is questioned²⁴. Contractual compliance (*pacta sunt servanda*) is the highest principle and is crucial for the completion of high-risk, high performance missions, expeditions or any similar multi-tasked and stressful, especially long-term solitary confinement posts. Whereas in some extreme circumstances it would be unfair for one of the parties to insist on performance of the obligation strictly in accordance with the terms of the contract, which would be an excessive burden on the counter-party, the *rebus sic stantibus* clause cannot be a field for abuse, therefore the change in the economic or social situation and the negative effect for one of them, not previously foreseen by the parties, must be assessed objectively²⁵.

This effect may take the form of a threat of gross loss or excessive difficulties, and the change may not be only temporary. In this case, renegotiation of the contract might be possible in order to adjust its provisions to the changed relations or even to terminate the contract. However, it is only permissible if the change of relationship took place after the conclusion of the contract, which could not be reasonably foreseen and the party whose interest was violated cannot be expected to bear the risk of this change. Depending on the cause of the non-performance, it may be excused or unjustified. European contract law regimes provide for the limitation of liability in the event that the performance of a party has become impossible for reasons for which it is not responsible and which could not be foreseen at the time of the conclusion of the contract, or it was impossible to avoid the obstacle, overcome it, or avoid/overcome its effects.

With regard to non-pecuniary liabilities, the creditor may require the "performance of a specific" obligation; this is a legal remedy also applicable in the event of defective performance. While it is usually the last resort for courts in most types of contracts, personal performance by a person trained and skilled to do it, in accordance with the original aim and wording of the contract, is crucial for the success of a given endeavor. Humans have the most adaptable abilities on

²⁴ C-W Canaris, H.Ch. Grigoleit, op. cit., pp. 445 et. seq.

²⁵ L. Olsen, The choice of the aggrieved party – An analysis of the remedies in the Principles of the European Contract Law, ERPL 1/1999, Kluwer Law International.

Earth. Human cognitive and perceptual psycho-motor performances deteriorate under different kind of stressors. Understanding the neurophysiological and neuropsychological parameters influencing difficult conditions is of high relevance to wide group of scientists including neuroscientists and psychologists. Environmental characteristics specific to prolonged isolation may influence neurophysiological and psychological efficiency.

IMPROVING THE ODDS OF PROPER CONTRACT PERFORMANCE THROUGH BIOMEDICINE

There are tools and procedures that have been developed to assess and deal with deficits and problems defined above. It is yet unknown how the brain will adapt e.g. to long-term travel to low Earth orbit and beyond²⁶. Perceptions of working in difficult conditions are affected by two important factors: motivation and stress. This could obstruct effective goal execution, as well as create stress among the people involved²⁷. The important necessity appears to identify markers of differential vulnerability to changes during the prolonged isolation and the need to ensure maintenance of circadian entrainment, sleep quality and quantity during exploration missions. Successful adaptation to such conditions will require crew prepared to surface habitats that instantiate aspects of Earth's geophysical signals²⁸. There is a close correlation between human stress and motivation and EEG Power Spectrum of Beta and Alpha band²⁹.

Numerous publications provide evidence that stressful early life experiences (e.g. social isolation) can affect brain development and influence behavior. There is also evidence to suggest there are different responses between sexes to stress. Although the underlying mechanisms are still poorly examined, it seems to be clear that in humans similar environmentally-induced changes could be considered as main factors in the basis of psychiatric disorders such as schizophrenia, depression or anxiety disorder. Moreover, isolates need more time to enter a new environment, they show neophobia and increased defecation in the open field. Most studies shows no effect of social isolation on the basic corticosterone level, others demonstrate either increased or reduced basal corticosterone levels after social isolation. According to both 'physical' and 'physiological' stress treatments,

²⁶ G. De la Torre, *Cognitive Neuroscience in Space*, *Life*, 4/2014, pp. 281-294.

²⁷ M. Gällstedt, Working conditions in projects: perceptions of stress and motivation among project team members and project managers, *International Journal of Project Management*, Volume 21, Issue 6, August 2003, pp. 449-455.

²⁸ M. Basner, D. Dinges, D. Mollicone, A. Ecker, Ch. Jones, E. Hyder, A. Di Antonio, I. Savelev, K. Kan, N. Goel, B. Morukov, J. Sutton, *Neuroscience Mars 520-d mission simulation reveals protracted crew hypokinesia and alterations of sleep duration and timing*, *Proc Natl Acad Sci. USA*. 2013, Feb 12; 110(7), pp. 2635-2640.

²⁹ Hayatee N., Hamid A., Sulaiman N., Siti Armiza Mohd Aris, Zunairah Hj Murat, Mohd Nasir Taib, *Evaluation of human stress using EEG Power Spectrum*, *IEEE*, 2010 6th International Colloquium on Signal Processing its Applications.

the release of adrenocorticotrophic hormone and corticosterone were found to be increased (adrenocorticotrophic hormone injection; open field exposure; foot-shocks) or unchanged following social isolation (forced swim)³⁰.

However, there is growing evidence to suggest the miRNA profiling can be an effective biomarker to be used in prognosis of disease and, more interestingly, there is a growing body of knowledge to suggest that specific miRNAs are altered in response to altering stress induced environments. Furthermore, it has been well documented that dysregulation of amygdala neural circuitry—a brain region associated with emotions—is central to the development and maintenance of symptoms experienced by subjects with post-traumatic stress disorder³¹ study of the individually determined upper alpha frequency band in EEG (electroencephalogram) was investigated as a neurofeedback parameter.

Fourteen subjects were trained on five sessions within 1 week by means of feedback dependent on the current upper alpha amplitude. The author responsible for the biomedical part of the present research tested cognitive ability on the first and fifth session using a mental rotation test. Results showed significant training success. Individually determined upper alpha was increased independently of other frequency bands. The increase in the level of cognitive performance was significantly larger for the neurofeedback group than for the control group, who did not receive feedback. The increased level of cognitive control went along with an increased upper alpha amplitude that was found in the neurofeedback group only. Neurofeedback may help remedy chronic post-traumatic stress disorder. Results demonstrated in this population can be implemented to all stress disorder subjects³². The cellular stress response is evolutionarily conserved in all living organisms, and a significant role is attributed to many molecules that confer stress protection.

The molecular responses elicited by the cells dictate whether the organism adapts, survives, or, if injured beyond repair. Most of the time these responses are beneficial to the organisms. Our detailed understanding of stress responses has paved the way for the development of stress tolerant crops in several instances. Considering all these, studies on stress responses turned out to have broad bio-

³⁰ I. Weiss, Ch. Christopher Pryce, A. Jongen-Rêlo, N. Nanz-Bahr, J. Feldon, Effect of social isolation on stress-related behavioural and neuroendocrine state in the rat. *Behavioural Brain Research*, Volume 152, Issue 2, 9 July, 2004, pp. 279-295.

³¹ Nicholson A., Rabellino D., Densmore M., Frewen P., Paret Ch., Kluetsch R., Schmahl Ch., Théberge J., Neufeld R., McKinnon M., Reiss J., Jetly R., Lanius R., The neurobiology of emotion regulation in posttraumatic stress disorder: Amygdala downregulation via real-time fMRI neurofeedback, *Human brain mapping* Volume 38, Issue1, January 2017, pp. 541-560. B. Zoefel, R. Huster, Ch. Herrmann, Neurofeedback training of the upper alpha frequency band in EEG improves cognitive performance, *NeuroImage*, Volume 54, Issue 2, 15 January 2011, pp. 1427-1431.

³² M. Askovic, A. Watters, J. Aroche, A. Harris, Neurofeedback as an adjunct therapy for treatment of chronic posttraumatic stress disorder related to refugee trauma and torture experiences: two case studies, *Australian Psychiatry*, 2017, Volume: 25 issue: 4, pp. 358-363.

logical applications in humans³³. Acute stress initiated by simulated severe intra-operative bleeding significantly influences (decreases) psychomotor performance during the acute stressful episode³⁴. There are detected stress reactions from muscle activity because of the possible benefits in prevention of musculoskeletal disorders. Several investigations were reported on the effect of mental stress on muscles. Experiments used the electromyography (EMG) from e.g. the upper trapezius muscle, from which various features were extracted to quantify muscle activity.

The Stroop color word test and different mental arithmetic tasks are the most popular ways to induce mental stress. The changes in EMG included an increase of amplitude and a decrease in the amount of gaps (short periods of relaxation) that were recorded. Both are indications of elevation of muscle activity, caused by the stress tasks. EMG could be an easily wearable wireless system that can measure real time stress levels³⁵.

2.2 OBJECTIVES

1. Defining the level of influence of the neurofeedback sessions in lowering the stress reaction level according to isolation on molecular, biochemical, neurophysiological, psychomotoric and psychological level.
2. Creating model profiles of stress response on molecular, biochemical, neurophysiological,
3. psychomotoric and psychological level according selected stressors.
4. Defining the effective number of neurofeedback sessions significant in lowering the stress level according to isolation.
5. Defining the most significantly informative areas (molecular, biochemical, neurophysiological, psychomotoric and psychological) according to negative influence of the isolation.
6. Identify differences in stress reactions and any potentially differences in recovery from stress between the sexes.
7. Identify a potential miRNA and/or DNA profiling signature to be used as a biomarker for a stress reaction and a recovery phase which can be used as a biomarker to monitor, evaluate and prescribe an intervention in an extreme environment.

³³ A. Grover A., Molecular biology of stress responses, Cell Stress Chaperones. 2002 Jan; 7(1), pp. 1-5.

³⁴ K. Bajunaid, M.A. Mullah, A. Winkler-Schwartz, F. E. Alotaibi, J. Fares, M. Baggiani, H. Azarnoush, S. Christie, G. Al-Zhrani, I. Marwa, A.J. Sabbagh, P. Werthner, R.F. Del Maestro, Impact of acute stress on psychomotor bimanual performance during a simulated tumor resection task, J Neurosurg. 2017 Jan;126(1), pp. 71-80.

³⁵ J. Wijsman, B. Grundlehner, J. Penders, H.J. Hermens, Trapezius Muscle EMG as Predictor of Mental Stress, Conference: Proceedings of Wireless Health 2010, WH 2010, San Diego, CA, USA, October 5-7, 2010.

8. Defining the level of impact of the results achieved in biomedical experiment in assurance of effective follow-up of prolonged costly task contracts.

2.3 HYPOTHESIS AND EXPECTED RESULTS

1. The neurofeedback sessions will significantly lower the level of stress experienced from isolation as also reflected in the molecular, biochemical, neurophysiological, psychomotorical and psychological profiling areas.
2. Lowering the stress level will increase the motivation of executing the tasks in extended time period.
3. The miRNA and/or DNA signature profile can we used to monitor non invasively an individuals response to and recovery from a stress induced environment.
4. Results achieved in biomedical experiment in assurance of effective performance will allow to handle “undefined” resignations from follow-up of prolonged costly task contracts.

Based on experiments already executed by the biomedical research expert, we can state that neurofeedback sessions effectively lower the stress level in molecular, biochemical, neurophysiological, psychomotoric and psychological areas (around 39%). The most significant results appeared according to prolonged physical effort. We believe that according to stressor (human isolation) the result will be similar and neurofeedback sessions will decrease stress level on various areas and will stabilize the motivation to execute difficult tasks in prolonged time period.

3. BENEFITS FOR HUMANS

Assistance on the ground in the form of psychological support is of vital importance for the tranquility of the crew members as well as for the pursuit of their personal objectives³⁶. The main benefit of the result of this proposed experiment is proposing an effective way of dealing with stress – lowering its level (using neurofeedback) connected with isolation as the main stressor and according to molecular, biochemical, neurophysiological, psychomotoric and psychological areas using individually prepared neurofeedback sessions performed during the isolation time period. In addition, the identification of a miRNA and/or DNA biomarker panel may assist in monitoring and evaluating an individuals response to and recovery to stress environment has patent potential. The information gained from these analyses may also assist us in understanding the diffe-

³⁶ D. A. Urbinan, R. Charles, Symposium keynote: Enduring the isolation of interplanetary travel. A personal account of the Mars500 mission, *Acta Astronautica* 93 (2014) pp. 374-383.

rences between male and female responses to and recovery from stresses. Based on the achieved results we will develop the score card to evaluate the stress level on various signatures and to prescribe the intervention procedure.

4. MANAGEMENT APPROACH

The project brings together a multidisciplinary team of researchers from Polish, South African, Ukrainian and Norwegian scientific institutions who have a proved track record in international, European, comparative and medical law, psychology, neurophysiology, psychomotorics and genomics. The individual team members are regarded as leaders in their respective fields as noted by the number of highly cited publications in their field of expertise. This multidisciplinary team will build on their existing knowledge and experience to execute the proposal, proliferate its outcomes and generate novel strategies to better characterize the impact of stress on human physiology which will enable the experiment-based approach to designing optimal legal doctrines and contract forms.

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