Zbornik 18. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2015

Zvezek C

Proceedings of the 18th International Multiconference

INFORMATION SOCIETY – IS 2015

Volume C

Kognitivna znanost
Cognitive Science

Uredili / Edited by

Olga Markič, Toma Strle, Urban Kordeš, Matjaž Gams

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8.–9. oktober 2015 / October 8th–9th, 2015
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PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2015

Multikonferenca Informacijska družba (http://is.ijs.si) je z osemnajsto zaporedno prireditvijo osrednji srednjeevropski dogodek na področju informacijske družbe, računalništva in informatike. Letošnja prireditev traja tri tedne in poteka na Fakulteti za računalništvo in informatiko in Institutu »Jožef Stefan«.

Informacijska družba, znanje in umetna inteligenca se razvijajo čedalje hitreje. V vse več državah je dovoljena samostojna vožnja inteligentnih avtomobilov, na trgu je moč dobiti čedalje več pogosto prodajanih avtomobilov z avtonomnimi funkcijami kot »lane asist«. Čedalje več pokazateljev kaže, da prehajamo v naslednje civilizacijsko obdobje, hkrati pa so konflikti sodobne družbe čedalje težje razumljivi.

Letos smo v multikonferenco povezali dvanajst odličnih neodvisnih konferenc. Predstavljenih bo okoli 300 referatov v okviru samostojnih konferenc in delavnic, prireditev bodo spremljale okrogle mize in razprave ter posebni dogodki kot svečana podelitev nagrad. Referati so objavljeni v zbornikih multikonference, izbrani prispevki pa bodo izšli tudi v posebnih številkah dveh znanstvenih revij, od katerih je ena Informatica, ki se ponaša z 38-letno tradicijo odlične znanstvene revije.

Multikonferenco Informacijska družba 2015 sestavljajo naslednje samostojne konference:

- Inteligentni sistemi
- Kognitivna znanost
- Izkopavanje znanja in podatkovna skladišča
- Sodelovanje, programska oprema in storitve v informacijski družbi
- Vzgoja in izobraževanje v informacijski družbi
- Soočanje z demografskimi izzivi
- Kognitonika
- Delavnica »SPS EM-zdravje«
- Delavnica »Pametna mesta in skupnosti kot razvojna priložnost Slovenije«
- Druga študentska konferenca s področja računalništva in informatike za doktorske študente
- Druga študentska konferenca s področja računalništva in informatike za vse študente
- Osma mednarodna konferenca o informatiki v šolah: razmere, evolucija in perspektiva.

Soorganizatorji in podporniki konference so različne raziskovalne institucije in združenja, med njimi tudi ACM Slovenija, SLAIS in Inženirska akademija Slovenije. V imenu organizatorjev konference se zahvaljujemo združenjem in inštitucijam, še posebej pa udeležencem za njihove dragocene prispevke in priložnost, da z nami delijo svoje izkušnje o informacijski družbi. Zahvaljujemo se tudi recenzentom za njihovo pomoč pri recenziranju.

V 2015 bomo tretjič podelili nagrado za življenjske dosežke v čast Donalda Michija in Alana Turinga. Nagrado Michie-Turing za izjemen življenjski prispevek k razvoju in promociji informacijske družbe bo prejel prof. dr. Jurij Tasič. Priznanje za dosežek leta je pripadlo dr. Domnu Mungosu. Že petič podeljujemo nagradi »informacijska limona« in »informacijska jagoda« za najbolj (ne)uspešne poteze v zvezi z informacijsko družbo. Limono je dobilo počasno uvajanje informatizacije v slovensko pravosodje, jagodo pa spletna aplikacija »Supervizor«. Čestitke nagrajencem!

Niko Zimic, predsednik programskega odbora
Matjaž Gams, predsednik organizacijskega odbora

FOREWORD - INFORMATION SOCIETY 2015

In its 18th year, the Information Society Multiconference (http://is.ijs.si) remains one of the leading conferences in Central Europe devoted to information society, computer science and informatics. In 2015 it is extended over three weeks located at Faculty of computer science and informatics and at the Institute "Jožef Stefan".

The pace of progress of information society, knowledge and artificial intelligence is speeding up. Several countries allow autonomous cars in regular use, major car companies sell cars with lane assist and other intelligent functions. It seems that humanity is approaching another civilization stage. At the same time, society conflicts are growing in numbers and length.

The Multiconference is running in parallel sessions with 300 presentations of scientific papers at twelve conferences, round tables, workshops and award ceremonies. The papers are published in the conference proceedings, and in special issues of two journals. One of them is Informatica with its 38 years of tradition in excellent research publications.

The Information Society 2015 Multiconference consists of the following conferences:

- Intelligent Systems
- Cognitive Science
- Data Mining and Data Warehouses
- Collaboration, Software and Services in Information Society
- Education in Information Society
- Facing Demographic Challenges
- Cognitonics
- SPS EM-Health Workshop
- Workshop »Smart Cities and Communities as a Development Opportunity for Slovenia«
- 2nd Computer Science Student Conference, PhD Students
- 2nd Computer Science Student Conference, Students
- 8th International Conference on Informatics in Schools: Situation, Evolution, and Perspective.

The Multiconference is co-organized and supported by several major research institutions and societies, among them ACM Slovenia, i.e. the Slovenian chapter of the ACM, SLAIS and the Slovenian Engineering Academy. In the name of the conference organizers we thank all societies and institutions, all participants for their valuable contribution and their interest in this event, and the reviewers for their thorough reviews.

For 2013 and further, the award for life-long outstanding contributions will be delivered in memory of Donald Michie and Alan Turing. The life-long outstanding contribution to development and promotion of information society in our country is awarded to Dr. Jurij Tasič. In addition, a reward for current achievements was pronounced to Dr. Domnu Mungosu. The information strawberry is pronounced to the web application "Supervizor, while the information lemon goes to lack of informatization in the national judicial system. Congratulations!

Niko Zimic, Programme Committee Chair
Matjaž Gams, Organizing Committee Chair

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Jožef Stefan Institute, Ljubljana

This year's Cognitive Science conference encompasses a wide variety of contributions from many different disciplines and approaches in cognitive science. Contributions from authors from four different countries include theoretical as well as empirical research. Theoretical work concerns critical evaluation of neuroscience, pharmaceutical cognitive enhancement or neuroenhancement, learning from conditionals, discussion on individual differences in reasoning and the possibility of coexistence of the mental models theory and the mental logic theory approaches, critical presentation of Koch's theory of consciousness and a discussion about forgetfulness at advanced age. Empirical research includes studies from psychology - how cognitive load during reading different texts is reflected in psychophysiological responses; linguistics - presenting a novel paradigm to disentangle the syntactic aspect of language processing from its semantic aspect; AI - discussing and applying a natural semantic metalanguage translator as a novel tool for cognitive modeling of emotions. This year focus is the phenomenon of pain. Authors tackle pain from interdisciplinary perspective and try to provide a framework where first person subjective reports, behavioral observations and knowledge of neural mechanisms will lead to better knowledge of pain. Such transdisciplinary approach incorporates multiple scientific, professional and practical dimensions into integrating knowledge of pain and will hopefully result also in better treatment of persons suffering from pain.

We hope this year's cognitive science conference, besides hosting excellent researchers, opens the space for networking, debate, and exchange of knowledge between disciplines and different ways of thinking about the mind — connecting local and international, young and seasoned researchers.

Olga Markič
Toma Strle
Urban Kordeš
Zala Kurinčič

Pain – a paradigm shift from transient to persistent pain

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ABSTRACT

In this paper, we 1) address major differences between transient and persistent pain 2) present overlapping and shared features in both cases; 3) discuss different methods and evaluation of pain 4) present most commonly used pain scale which reflects the diversity of our pain perception 5) overview a neurobiological model of transition from transient (acute) to persistent (chronic) pain 6) propose the paradigm shift in our pain perception when evaluating a patient with persistent pain.

General Terms

Measurement, Human Factors

Keywords

pain, experimental pain, acute pain, chronic pain, pain syndromes, pain scale

1. INTRODUCTION

Pain is a perception or a feeling triggered in the nervous system which signals the individual that tissue damage has occurred or may be occurring. The International Association for the Study of Pain defines pain as an unpleasant sensory and emotional experience associated with actual or potential tissue damage [1].

Pain has been among anaesthesiologists identified as the fifth vital signs in an attempt to facilitate accountability for pain assessment and management [2]. Evolutionary pain sensation was preserved because without feeling pain, you might seriously hurt yourself without knowing it, or you might not realize you have a medical problem that needs treatment. Once you take care of the problem, pain usually goes away. In addition, humans have been equipped with the capability of adding emotion to a sensation, which enhances self-protecting behaviour. Negative emotion which comes with pain allows people to be aware of and adjust to tissue trauma. However, sometimes pain occurs without an apparent cause which makes pain hard to comprehend.

Time frame divides pain into transient - acute or persistent – chronic pain. Transient pain lasts for a short time or is expected to be over soon, lasting from brief seconds to several weeks. Different situations and contexts influence our pain perception. Pain is perceived differently during the day in different situations (minor injuries, daily activity etc.). Acute pain in clinical settings (postoperative pain, pain related to different medical procedures) differs from experimental pain (thermal, mechanical, and chemical pain). Chronic pain is defined as pain lasting beyond the healing of an injury, from several months to even years. It often has no time limit and appears to serve no purpose or no clearly identifiable cause. However, persistent pain can originate from tissue trauma; e.g.: in patients who have conditions such as rheumatoid arthritis, after nerve damage or cancer. Health care professionals classify pain based on its characteristics, its cause, or the mechanisms in the body or the mind that are probably involved in sustaining it. One common classification based on mechanisms distinguishes pain into categories: nociceptive, neuropathic, and psychogenic [3].

Common observation is that some people fare well despite severe chronic pain while the others' life deteriorate in all areas. Some emotions, including sadness, anger and anxiety. There are important distinctions, including neurobiological, social, and

physiological factors, among acute and chronic pain which call for a paradigm shift in treating people with acute or chronic – persistent pain.

Having said this, we can understand that pain is an internal, subjective experience that cannot be directly observed by others or by the use of physiological markers or bioassays hence its assessment relies largely upon the use of self-report. Much effort has been invested in testing and refining self-report methodology within the field of human pain research [4, 5].

2. PAIN ETIOLOGY

Pain is distinguished according to the causative mechanisms into nociceptive, neuropathic and psychogenic pain. We also distinguish visceral or referred pain, central pain, radicular pain, neuralgia, deafferentation and sympathetically mediated pain (See Table 1).

Table 1: Different types of pain, classified according to the causes and physical examination.

Type of pain	Causative mechanisms	Clinical picture
Nociceptive	Activation of nociceptors which are located all over the body except the central nervous system (CNS) Due to tissue damage	Clinically proportional to the degree of activation of afferent pain fibers and can be acute or chronic (e.g.: somatic pain, cancer pain, postoperative pain), may not be proportionate to tissue damage Characterized as thermal (e.g.: hot, cold), mechanical (e.g.: crushing, tearing), and chemical (e.g.: chilli powder in the eyes)
Neuropathic	Due to nerve injury or disease, also involvement of nerves in other disease processes (e.g.: tumour, inflammation)	Burning, tingling, like ants crawling, pins and needles, awkward electrical feelings May occur in the periphery or centrally (in the CNS); e.g.: in metabolic diseases
Neuralgia	Associated with nerve damage or irritation along the distribution of a single nerve or nerves	Lancinating and distributed along the single or multiple nerves; e.g.: trigeminal neuralgia
Radicular	Evoked by stimulation of nociceptive afferent fibers in spinal nerves, their roots, or ganglia, or by ectopic impulse generation	Often appears together with radiculopathy
Referred or visceral	Due to spinal convergence of visceral and somatic afferent fibers on spinothalamic neurons; originates from a visceral organ	Cutaneous and deep hyperalgesia, autonomic hyperactivity, tenderness, and muscular contractions, which can be felt in body regions remote from the site of pathology
Central	Originates from a lesion in the CNS, usually involving the spinothalamic cortical pathways (e.g.: thalamic infarct)	Constant with a burning, electrical quality; exacerbated by activity or changes in the weather; hyperesthesia and hyperpathia and/or allodynia are invariably present, and the pain is highly resistant to treatment
Deafferentation	Results from loss of afferent input to the CNS, which is due to lesion in the periphery (eg, peripheral nerve avulsion) or in the CNS (e.g.: spinal cord lesions, multiple sclerosis)	Chronic
Sympathetically mediated	Results from coactivation of vegetative nerve system	Accompanied by evidence of edema, changes in skin blood flow, abnormal pseudomotor activity in the region of pain, allodynia, hyperalgesia, or hyperpathia
Psychogenic	Due to complex mechanisms, involving cognitive and emotional functions	Inconsistent with the likely anatomic distribution of the presumed generator or it exists with no apparent organic pathology

3. PAIN ASSESMENT

Pain is assessed with a multidimensional approach, with detailed history and physical examination. In evaluating pain we address the time component (duration, fluctuation); quality and quantity of pain; etiology and contributing factors. Psychological assessment should be comprehensive, including various questionnaires.

Initial assessment includes the onset of pain and progression in time. Clinical distinction between acute and chronic pain is set at either 3 or 6 months. Onset of pain may be described as abrupt and sudden or insidious and gradual. We describe the pain within the first 3-6 months from the onset time as acute pain. It usually starts abruptly and is often associated with traumatic injury. It may resolve within first 6 months without intervention. Chronic pain does not resolve within 3–6 months of its initiation and progresses beyond 6 months of duration. Sleep disturbances usually accompany chronic pain.

Contributing factors must be determined as they can point to causes as well as consequences of pain. Nociceptive symptoms can be amplified by certain body positions and activities, which are disturbing to the patient's quality of life. Chronic pain may lead to antalgic gait or positions with the tendency to generally avoid movement.

Etiology should be determined. With acute pain trauma and mechanism of injury should be determined, too. Repeated microtrauma over a long period of time may lead to degenerative, insidious, and chronic painful situations. When mechanism of

injury is not obvious, some common diseases should be kept in mind: autoimmune diseases, mass effect from neoplastic process, tissue damage from metabolic processes etc.

As pain assessment is based on patient's report, which makes evaluation more difficult in non-verbal patients and in children. People also experience different thresholds. The pain perception threshold is the point at which the stimulus begins to hurt, and the pain tolerance threshold is reached when the subject acts to stop the pain. The variability of pain threshold is apparent individually, within community, but is also between patients of different sex, ethnicity, and race [3].One of the most difficult challenges in chronic pain management is recognizing patients who are exaggerating their symptoms for secondary gains, including patients who abuse prescription opioids [6].

Chronic pain syndrome (CPS) presents a major challenge because of its complex natural history, unclear etiology, and poor response to therapy [7].
In etiology of chronic pain psychological factors play an important role (e.g.: importance of reinforcement of pain behaviour, locus of control, dysfunctional coping strategies). Patients with chronic pain have a high comorbidity with psychopathology (e.g: depression, anxiety disorders, PTSD, somatisation disorder). Whether psychopatology is antecedent to, a consequence, or due to cognitive-behavioural mediation in pain disorders, it is still unclear.

A connection was found between the number of active myofascial trigger points (MTrPs) and the intensity of spontaneous pain, as well as widespread mechanical hypersensitivity. Nociceptive inputs from these MTrPs may be linked to central sensitization [8]. Errant nerve impulses keep alerting CNS about tissue damage that no longer exists, if it ever did. Complex social and psychological factors in addition blur the picture.

4. MEASURING PAIN

Pain is subjective expression making objective measurements hard. The measures we use currently fall into two categories: single-dimensional scales and multidimensional scales, that usually measure pain intensity, temporal aspects of pain, and pain quality. Other related dimensions, specifically pain behaviour, pain interference, and composite pain measures that combine pain intensity ratings with other dimensions, will not be reviewed here.

Unidimensional scales measure one dimension of the pain experience, usually intensity. The three most commonly used methods to quantify the pain experience include verbal rating scales, numeric rating scales, and visual analogue scales. They are accurate, simple, quick, easy to use and understand and are commonly used for acute pain assessment.

Multidimensional scales provide information about the qualitative and quantitative aspects of pain and may be useful if neuropathic pain is suspected. They require patients to have good verbal skills and sustained concentration, as they take longer to complete than uni-dimensional tools. Different questionnaires fall into this category, e.g.: McGill pain questionnaire (short and long), Brief Pain Inventory (short and long), Multidimensional Pain Inventory etc.

5. NEUROBIOLOGICAL MODEL

The biopsychosocial model of pain proposed that biological factors can influence physiological changes. Psychological factors are reflected in the appraisal and perception of internal physiological phenomena, which are in turn influenced by social or environmental factors [9]. The process goes in both directions, so psychological and social factors also influence biological factors, such as hormone production, activity in the autonomic nervous system and physical deconditioning.

Data show, that pain in infancy influences pain reactivity in later life which is probably due to developmental plasticity of nociceptive pathways. Adults who have experienced neonatal injury display increased pain and injury-induced hyperalgesia in the affected region but mild injury can also induce widespread baseline hyposensitivity across the rest of the body surface, suggesting several underlying mechanisms, depending upon the type of early life experience [10]. Peripheral nerve sprouting and dorsal horn central sensitization, disinhibition and neuroimmune priming increase pain and hyperalgesia. Altered descending pain control systems, which is due partially by changes in the stress/HPA axis but on the other hand lead to the widespread hypoalgesia. Increased neonatal

HPA-axis responses to stress, immune challenges follow, which are later associated with an anxiety-like phenotype in adults [11]. In pain detection endocannabinoid system seem to play a role, too. The system is well developed at birth and regulates presynaptic neurotransmission in the first few years of human life [12]. It also suppresses rapidly neonatal physiological stress response.

Specific neurobiological mechanisms underlying injury-induced plasticity in the developing pain system may be the promising therapeutic target in future.

6. PARADIGM SHIFT

Pain is not a simple sensation that can be easily assessed and measured. Being invisible and highly subjective makes it difficult to evaluate and measure. Changing the paradigm from seeing a pain as a result of visible trauma which is going to be cured by a doctor to a complex sensation which involves brain plasticity and specific biochemical pathways requires a challenging mind. Through research, reading, and requested tests, we have just started to discover what does chronic pain mean.

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FORGETFULNESS IN OLD AGE: A PRO-SOCIAL TRAIT?

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ABSTRACT

During the evolution of the genus homo, longevity appears to represent an important trait. This may have allowed for the appearance of one section in human societies specializing in the tradition of preserving knowledge. Therefore, such individuals may have been selectively predisposed to old memories by the neurobiological weakening the formation of new memories. By that, forgetfulness at advanced age might have developed as advantage for the society and should not be regarded as pathological trait.

Categories and Subject Descriptors

J.3 [**Life and Medical Sciences**]: Biology and genetics; Health

General Terms

Human Factors, Theory

Keywords

Human aging, human memory, neurobiology of aging, cognition in old age, evolution, human longevity

INTRODUCTION

Forgetfulness is a common behavioral symptom of aging humans. It may progress to dementia, but usually afflicted individuals learn to handle their inconvenience and continue an independent life. The neurobiological basis of age-related memory decline is a target of intense clinical and neuroscientific research. Neuropathological and cognitive indications point to a slowly developing trait extending over decades. Human societies heavily depend on the tradition of knowledge slowly accumulating over many generations. This process includes an important role of elderly people as the source of information to be conserved.

AGE-REALTED CHANGE IN HEALTHY ELDERLY

The positive changes that occur with age and the on average preserved abilities [1] seem to paint a picture of elderly individuals as sources for wisdom and societal support. Their intact and even superior verbal fluency [2] and vocabulary [3] in combination with their positivity bias [4] and less impact of stress on decision making [5] makes them good and honest advisors for their kin. Their ability to pass on skills, traditions, values and history make them valuable members of a collective, if not essential. Hence, forgetfulness may have the serendipitous effect of bringing the elderly individuals closer to their community and thus also sharing not only the collective effort of memory support but also assuring the passing on of their knowledge and experience.

HUMAN LONGEVITY AND FORGETFULNESS

Grandmother hypothesis as a model

The grandmother hypothesis of human longevity has been given support in theoretical as well as evolutionary research and modelling [6]. Here, we propose that forgetfulness in old age plays an equally important part in the evolution of human longevity, as it provides incentive for support from society, be it a close community or family which provides the necessary care and social contribution in a serendipitous fashion.

IMPLICATION FOR ELDERLY IN THE COMMUNITY

Forgetfulness might act as an incentive for elderly to live in close group communities which then acts as a memory buffer as well as overall support in daily living. In this way, forgetfulness creates a potential bonding between the elderly individual and his/her family and community and this closeness and good social bonds, have in turn been shown to contribute to lengthen the lifespan compared to individuals who live alone or have very limited social stimulation

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Kochove meritve zavesti

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POVZETEK

V prispevku je predstavljen Kochov pristop k merjenju zavesti, tj. poglobljena in razširjena analiza predstavitve Cristofa Kocha na konferenci IJCAI 2016. Nekaj spoznanj je bilo za strokovnjake umetne inteligence novih, recimo iskanje minimalne zavesti ali metoda za numerično merjenje zavesti.

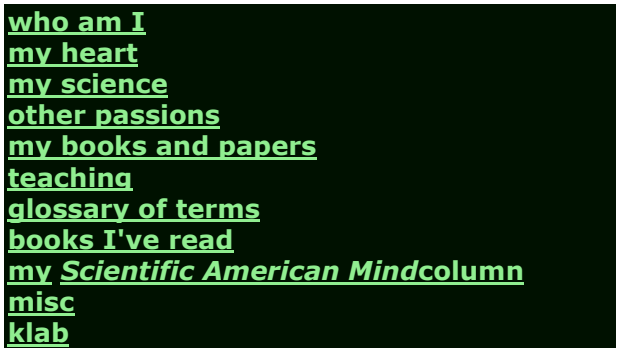
Ključne besede

Surpassing human brains, future prediction, artificial intelligence

1. UVOD

Po podatkih Wikipedije se je Christof Koch rodil v Ameriki, odraščal pa je na Nizozemskem, v Nemčiji, Kanadi in Maroku. Na univerzi v Tübingnu, Nemčija je študiral fiziko in filozofijo in pridobil akademski naziv doktorja znanosti s področja biofizike. V Ameriki je deloval na MITju, kalifornijskem Institute of Technology, nato je postal »Chief Scientific Officer« na »Allen Institute for Brain Science«. Vodi desetletni obsežni projekt raziskovanja cerebralnega korteksa pri miših in ljudeh.

Christof je objavil več kot 300 znanstvenih člankov in referatov, ima osem patentov, napisal je pet knjig o procesiranju informacij pri ljudeh in računalnikih. Je dolgoletni sodelavec nobelovca Francisa Cricka. Oba sodita med pionirje raziskav zavesti. Njegova zadnja knjiga ima naslov »Consciousness – Confessions of a Romantic Reductionist« [1]. Pogosto nastopa v javnosti in ima svojo kolumno v reviji Scientific American na temo Mind. Njegova domača stran (http://www.klab.caltech.edu/koch/; kazalo je na sliki 1) tako kot slike (npr. dve na sliki 2), dostopne na Googlu, kažejo njegovo vsestransko pojavo in razmišljanje.



Slika 1. Kazalo na domači strani Cristofa Kocha kaže nenavaden poglede enega vodilnih raziskovalcev zavesti.

Morda tudi zaradi svoje ekstravagance je omenjeni avtor dokaj neprepoznaven v sferi umetne inteligence. Npr. njegova knjiga [1] se namenoma v uvodu pogosto začenja z »jaz«, tj. angleško »I«, čeprav je to v znanstvenih objavah prepovedano oz. skrajnje nezaželeno. Njegova popularnost v krogih UI pa se je spremenila po vabljenem predavanju na največji svetovni konferenci o umetni inteligenci, IJCAI 2015 [2].

Tam je predstavil troje zanimivih tem:

- minimalni pogoji za zavest
- postulati zavesti
- numerična funkcija za izračun stopnje zavesti.

V tem prispevku se zgledujemo predvsem po članku Giulio Tononi, Christof Koch: Consciousness: here, there and everywhere?, objavljenem leta 2015 [3]. Ta prispevek je skladen s predavanjem na konferenci IJCI 2015. Osnovni prispevki v zadnjem desetletju, na katere se sklicuje Koch kot najpomembnejše za znanstveni pristop k raziskovanju zavesti, so [4,5,6,7].

Slika 2. Cristof Koch je eden vodilnih pionirjev raziskav zavesti, raziskovalec z mnogo odkritji in pojavami, kar kažeta tudi prikazani sliki.

2. KOCHOVI POTREBNI POGOJI ZA ZAVEST

Pri ljudeh je na videz enostavno ugotoviti, ali je oseba zavestna ali ne. Npr. pogovorimo se oz. na nek način komuniciramo (podobno Turingovim testom) in hitro dobimo vtis. Pri tem so lahko posamezniki nesposobni fizičnega premikanje, kot je npr. Stephen Hawking, ki je zaradi bolezni zmožen premikati le še obrazno mišico. Še pred meseci je uspel premikati en prst, sedaj pa nič več. S posebej prilagojeno napravo pa iz premikanja te mišice sestavijo besedilo in pogosto so njegove misli svetovno odmevne. Tako je npr. pred nedavnim opozoril na nevarnost, da bo umetna inteligenca zavladala človeški rasi, njegovo opozorilo pa so predvajali vsi svetovni mediji.

Torej sposobnost fizičnega premikanja ni pomembna, so pa drugi minimalni pogoji: da možgani delujejo, da srce utripa (lahko je tudi umetno) itd. V fizičnem smislu je vprašanje, ali je človek

zavesten, če mu deluje le del možganov oz. kolikšen del živčne mase lahko izgubi. Študije kažejo, da je miminalni obseg pol možganske skorje in da lahko osebe izgubijo celo skoraj vse ostale dele možganov, pa so lahko zavestni. Kljub temu se dogajajo določene težave, npr. pri izgubi korpus kalozuma se pojavljajo težave z enovito osebnostjo, lahko se zgodi, da se pojavljajo konfliktne podosebne lastnosti itd. Podobno pri izgubi delov možganov, ki skrbijo za vid ali telo sledi izguba sposobnosti zaznavanja in upravljanja s tem fizičnim sistemom.

Naslednje vprašanje je, katero mentalno lastnost lahko izgubimo, pa vseeno ostanemo zavestni. Izkaže se, da lahko izgubimo čustva, samozavest in še mnogo kognitivnih lastnosti, pa ostane oseba z zavestjo. Morda okrnjena ali celo močno okrnjena, pa vendar jo sprejemamo kot človeško bitje z zavestjo.

Ta spoznanja so skladna s pristopom »prave« **kognitivne oz. moderne znanosti, ki skuša konkretno empirično raziskovati teme zavesti in kognicije**. Descartov »je pense, donc je suis« ostaja bistvo kognitivne definicije zavesti, temelječe na tem, da jo lahko človek na način Turingovega testa prepozna. Na tem pristopu pa sledi množica modernih znanstvenih eksperimentov in ugotovitev, npr. omenjene zgoraj.

Poleg zgoraj omenjenih dokaj nespornih ugotovitev pa obstaja veliko čedalje bolj zapletenih tem. Npr. oseba hodi in govori, ampak to počne v spanju. Ali pa spi in je na videz neodzivna, ampak intenzivno sanja.

Koch skladno z drugimi strokovnjaki ugotavlja, da je smotrno definirati minimalno nevronsko strukturo, ki omogoča kognitivne procese [4,8,9]. Podoben pogled temelji na možganih, ki oddajajo določene EEG valove – samo zadostna količina valov omogoča zavest. Težje pa je določiti mejo za zadostno količino valov, ki še omogoča zavest. Koch navaja 6 zapletenih primerov:

- hoja v spanju
- anestezija
- vegetativni pacient
- zarodek ali nedonošenček
- nenavadne živali kot npr. hobotnica
- računalniki, roboti.

Pri poškodbah glave na urgenci preverjajo zavest oz. odzivnost pacientov, vendar nobena meritev ni povsem zanesljiva. Tako so lahko na zunaj neodzivni pacienti, katerim pa se možgani odzivajo glede na vprašanje. Torej so možgani razumeli vprašanje, čeprav pacient deluje na zunaj povsem pasivno. Po drugi strani pa včasih možgani ne oddajajo »normalnih valov«, pa vseeno pacienti komunicirajo zavestno. Pri zarodkih se možganski valovi pojavljajo najprej pri okoli 6 mesecih, kar postavlja vprašanje, ali so tudi mlajši zarodki zavestni ali ne. Podobno vprašanje je pri testiranju pacientov, ki imajo normalno delujoč del možganske skorje in kažejo nekatere normalne zavestne funkcije, mnogo drugih zavestnih funkcij pa je odsotnih.

Pri živalih je po Kochu zadeva naslednja: Če pogledate nevrone pri slonih ali miših, jih brez mikroskopa ne ločite. Poleg tega so živali sposobne dojemati okolje in reagirati, torej kažejo določene stopnje zavesti. Ta zavest gotovo ni na človeške nivoju, ampak na vprašanje, ali je 0, je odgovor negativen. Po Kochu imajo vse višje živali določeno zavest.

Naslednje vprašanje je, kaj je z nižjimi živalmi. Zopet išče odgovor v notranji strukturi in delovanju navzven, tj. sposobnosti učenja in prilagajanja. Čebele imajo 800.000 živčnih celic v možganih, ki delujejo funkcionalno podobno kot človeške celice. Ribe in hobotnice so se sposobne naučiti raznolikih trikov. Vseeno Koch svari, da je morda ta »zavest« na bistveno nižjem nivoju. Recimo pri tipkanju na tipkovnico lahko prste nadzorujemo zavestno, pogosto pa prsti uporabljajo neke svoje živčne mehanizme, ki bi jih težko imenovali »zavestne«. Morda nižje živali delujejo podobno – so se sposobne učiti, so sposobne reagirati na okolje, vendar je njihov nivo hudo preprost.

Zapleteno je tudi vprašanje, ali imajo računalniki zavest. Ljudi premagujejo na čedalje več področij, pa naj bo to šah ali avtonomna vožnja avtomobila. Funkcionalno gledano je to sposobnost zavesti, saj bi za ljudi s temi sposobnosti gotovo rekli, da so zavestni. Po drugi strani pa nimajo primerne nevronske strukture, oz. logično-informacijske, zato je za tovrstna vprašanja potrebno poseči po bolj metodoloških znanstvenih pristopih.

3. KOCHOVI POSTULATI IN AKSIOMI ZA ZAVEST

Kot odgovor na omenjena vprašanja in dileme Koch predlaga integriran znanstveni pristop – integrated information theory (IIT). Najprej predstavi aksiome in nato postulate.

Kochova integrirana oz. celovita informacijska teorija temelji na določitvi minimalnih pogojev za obstoj zavesti, nato pa sledi določitev primerne informacijske in fizične strukture za določeno funkcionalnost.

Aksiomi naj bi imeli določene lastnosti kot neprotislovnost, polnost, neodvisnost, itd. Kochovi aksiomi skušajo v čimvečji meri realizirati zaželene aksioatske lastnosti. V izvirniku so aksiomi: 1 intrinsic existence (izvorna eksistenca), 2 composition (sestava), 3 information (informacija), 4 integration (integracija) in 5 exclusion (izključitev). Prikazani so na sliki 3 na koncu prispevka skupaj s postulati. Postulati so pogoji fizičnih struktur za doseganje določene lastnosti zavesti, napisane v obliki aksioma.

3.1. Izvirna eksistenca

Aksiom: Zavest obstaja in je v ljudeh, tudi v meni in vas, skladno z Dekartom. Postulat: Zavest je sposobna razumeti vzrok in predlagati posledico.

3.2. Sestava

Aksiom: Zavest je strukturirana in ima svojo sestavo. Postulat: Zavest je strukturirana in poddeli zavesti imajo tudi lastnosti zavesti.

3.3. Informacija

Zavest je specifična in zajema določene izkušnje na specifičen način. Postulat: Zavest omogoča razlikovanje med specifičnimi vzorci vzrok-posledica in tako omogoča diferenciacijo delovanja.

3.4. Integracija

Aksiom: Zavest je enotna in ne omogoča razgradnje v podkomponente. Postulat: Fizična struktura mora biti integrirana, tj. nerazstavljiva. Ta lastnost je s simbolom označena kot Φ.

3.5. Izključitev

Aksiom: Zavest je določena z vsebino, prostorom in časom in omogoča ločevanje med izkušnjami. Postulat: Realizacija zavesti mora omogočati ločevanje možnih vzrokov in posledic in najti tisto, ki je najprimernejša v izbranem kontekstu.

4. KOCHOV IZRAČUN STOPNJE ZAVESTI

Aksiomi skupaj s postulati pripeljejo do konceptualne strukture zavesti, ki je "maximally irreducible intrinsically", oziroma "quale". Na osnovi tega postavi matematično formulo za izračun kvantitativne ocene zavesti, označene s Φ^{max}. Če je Φ^{max} večji kot 0, je prisotna neka stopnja zavesti - večja je številka, večja je stopnja zavesti. Ta numerična funkcija je osnovana na arhitekturi informacijske oz. mentalne strukture. S tem je možno v precejšnji meri pojasniti prejšnje primere: ko se izgubljajo lastnosti zavesti, npr. sposobnost integracije zaradi spanja ali poškodbe, se zmanjša tudi numerična ocena funkcije.

Omenjeni pogled omogoča določene nove sklepe, denimo da je tudi odsotnost določenih mentalnih oz. »spečih nevronov« pomembna za sklepanje – odsotnost pač povzroči drugačno strukturo. Drug možen sklep je, da ob zmanjševanju zavesti pride do razpada zavesti na dva dela – to je dokaj redki, a znani primer razdeljenih osebnosti. Možne so tudi razlage nenavadnih pojavov, recimo izgube zavesti med spanjem, čeprav so možgani med sanjami aktivni – znova v skladu z omenjenimi aksiomi in postulati.

Med posledicami IIT teorije, tj. teorije z aksiomi in postulati so tudi naslednje ugotovitve:

- zavest je fundamentalna lastnost, neodvisna od opazovalca

- zavest je lahko šibkejša ali močnejša (izračun s Φ^{max})

- zavest je prilagodljiva

- zavest ima več nivojev (se pa ne strinja, da obstaja zavest npr. skupine živali; povezava med različnimi komponentami mora biti skladna z aksiomi)

- zavest je mnogotera (dopušča možnost za sobivanje zavesti znotraj enega sistema)

- združbe niso zavestne (npr. ZDA nimajo ene zavesti, oz. več sistemov s $\Phi^{max} = 0$ ne dvigne končno Φ^{max} na več kot nič)

- kompleksni sistemi so lahko brez zavesti (mnogi mehanski ali informacijski sistemi imajo $\Phi^{max} = 0$, čeprav so očitno zelo zapleteni. To lepo pojasni, zakaj popolen tabelarični pristop (vse informacije so v tabelah) ali vsi sistemi brez zank ne morejo postati inteligentni, čeprav znajo rešiti vse naloge oz. odgovoriti na vsa vprašanja. Koch sicer trdi, da bi v tem primeru rešitve Turingovega testa (kar naj bi bilo po njegovem zagotovljeno z dovolj velikim tabelaričnim pristopom), vseeno manjkala zavest, torej TT ni primeren (podobno zgrešen je tudi Searlov paradoks, saj predpostavi nekaj, kar je neuresničljivo). Njegova trditev je po mnenju tega avtorja neosnovana, saj obstajajo znanstveni prispevki, ki dokazujejo, da tabelarični pristop ne more rešiti marsikaterega vprašanja.

Zanimiva je misel, da računalniki po njegovem niso zavestni. Za začetek zato, ker simulacija ni realni proces. Simulacija črne luknje namreč ne ukrivi prostora v realnem prostoru in zato tudi simulacija zavesti ni zavestna v realnem svetu. Glede na strukturo računalnikov (elektronika) je verjetno obstoječa računalniška struktura premalo povezana oz. ne izpolnjuje aksiomov.

5. DISKUSIJA

Je Koch (s sodelavci, oz. precejšen del njegove teorije je pobral iz literature, kar korektno citira) dokončno definiral zavest v obliki aksiomov, postulatov in numerične funkcije? To bi bil izjemen rezultat. Nekatere njegove misli so gotovo velik izziv, recimo ona, da simulacija črne luknje ne krivi prostora, to pa velja tudi za simulirano zavest. Čeprav so v njegovem predavanju in tudi v članku določene vprašljive, če ne celo napačne teze, pa je njegov pristop verjetno najboljši poskus znanstvenega opisa zavesti. Kot tak bi moral najti pot v vse učne programe kognitivnih znanosti v Sloveniji.

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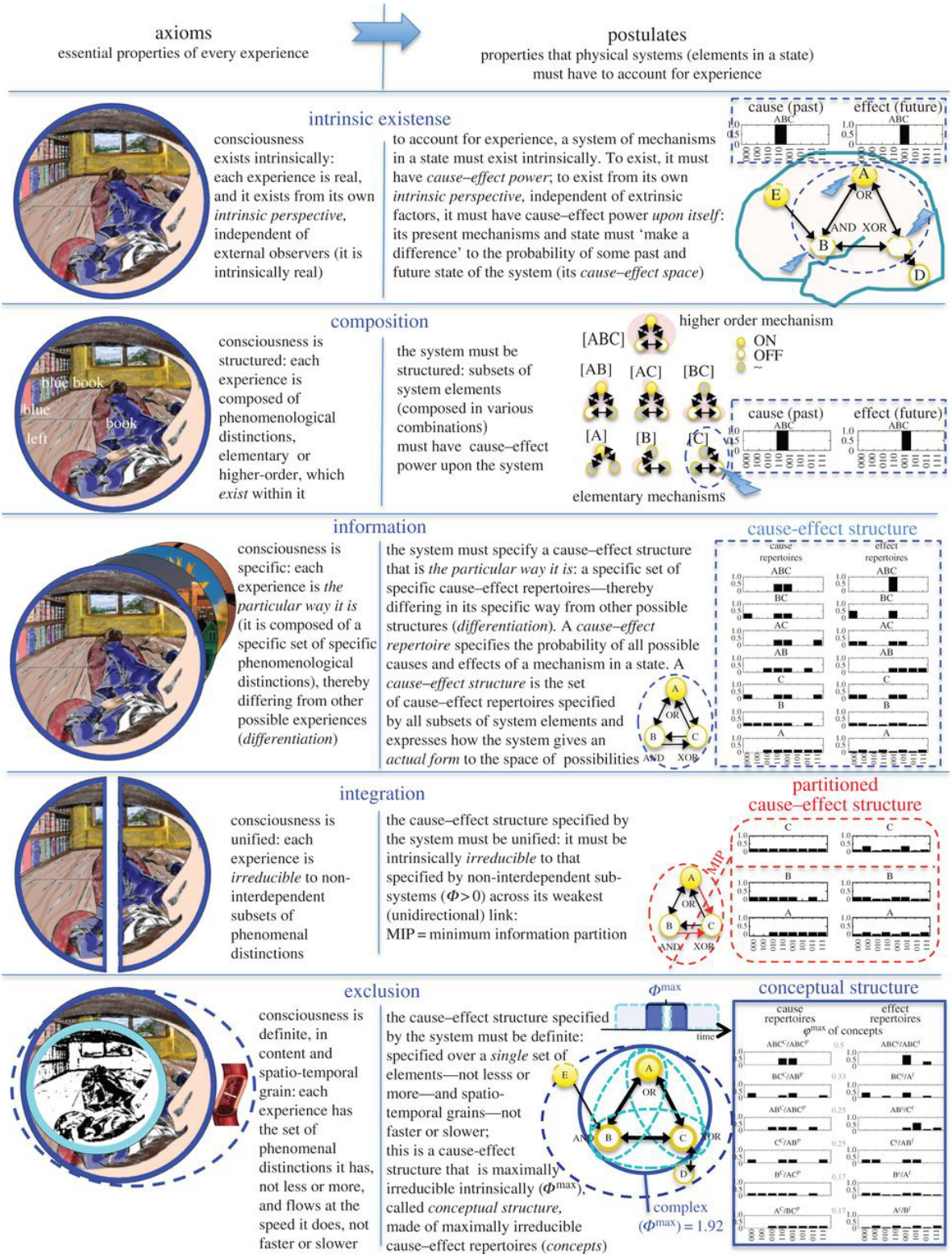

Figure 3. Kochovi aksiomi in postulati za zavest, objavljeni v [3].

Psychological Approach to Pain as Transdisciplinary Phenomenon

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ABSTRACT
Pain is individual experience, whose subjective nature makes it difficult to define, describe and measure. The importance of recognizing, assessing, understanding and managing pain is central to the sufferers. When a person with pain presents to others, he rarely comes labeled with a given diagnosis; rather, he more often has a chief "complaint", i.e. symptom, not the pathology or disease. We have to respect and understand that pain and suffering could be very embarrassing.
Psychological factors are central to the experience of pain and frequently decisive in effective management. By translational approach are psychological decisions indispensable by seeking creative solutions to these complex challenges. Transdisciplinary approach incorporates multiple scientific, professional and practical dimensions into integrating knowledge of pain. This worldwide health problem will be manageable with synergistic approach of traditionally separated disciplines. Pain problems are persistent and solutions are because of complex interdependencies difficult to recognise. Identified solutions may span several generations and be characterised by lags and inertia. Long lasting problems will be solved by new knowledge which will be set up by integrated research studies, interventions, advancing theory and methodology.

General Terms
Management, Measurement, Documentation, Experimentation, Human Factors, Standardization, Theory, Verification.

Keywords
Critical research, Disciplinarities, Pain, Physiology, Problem-solving research, Psychology, Psychophysics, Sensation, Translational approach

1. INTRODUCTION
Pain is a self-reported subjective experience, the presentation is complex and the management should be interdisciplinary. Comparisons of chronic pain complaint in health care and improvement in pain management can often be well established. These changes can have significant effects in the experience of pain, distress and use of health-care resources [14].

Pain is one of the few research, professional and practical disciplines that rely heavily on individual self-reporting. This ubiquitous, crossdisciplinary experience is an integral part of life and don't have just important protective function. It is not disease neither behavioural issue but is transdisciplinary phenomenon.

This multidimensional, universal experience is modulated by many afferent and efferent mechanisms [27]. They determined this subjective phenomenon, depending on interaction of innate and acquired responses. It has many different, i.e. sensory, emotional, cognitive and behavioural components, and could be depicted on diverse, i.e. verbal-subjective, motor-behavioural and physiological levels [35]. Pain may or may not involve nociceptive input, but is always tied to physiological antecedents and consequences (psychobiological view) [11].

Pain research faces enormous challenges, and there remain many obstacles in the management of unpleasant and potentially dangerous sensation [5, 6, 10]. There is clearly permanent need for multidimensional and meaningful translational pain research [19]. Traditionally, integration and holism invoked approach that is regarded as extenuating process of integrated and coordinated multidirectional intra-, multi-, cross-, inter- and transdisciplinarly integrated complex problem solving [18].

2. INTEGRATED PAIN RESEARCH
Modern integrated scientific, professional and practical methods were positively stimulated by development of traditional disciplinary approaches. They provide frames of reference, methodological approaches, topics of study, theoretical canons, and technologies [36]. The linked nature of human, biophysical and biopsychosocial systems requires breakthroughs of scientific boundaries that prevent shared understandings of complex issues.

Integrated pain-oriented research studies link interactions across domains as well as the past, present and possible futures. They combine research on the character and distribution of the pain in accord with criteria, cause as i.e. relevant lesion, process, or disease, that are probably responsible for the pain. [16]

3. PSYCHOLOGY IN INTEGRATED PAIN DOMAIN
Pain is a major health problem in society, affects millions of people and represents increased proportion of health care costs. This severe medical illness is a worldwide phenomenon. It continues to indicate that even with therapeutic intervention inadmissibly percent of people report inadequate pain relief, pain

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of moderate or greater intensity [7, 17, 32] and incalculable human suffering.

This subjective experience is a complex perceptual phenomenon involving all domains of person's life. It emphasized psychological, physiological, social, cognitive, behavioural, somatic etc. factors. According to definition of this unpleasant sensation pain could not be evaluated as phenomenon "*per se*" [35]. We favour and recommended approach "people with pain" rather than "pain as phenomenon *per se*". Pain is namely a strict subjective experience, it occurs within a broad context with factors that influence subject's individual experience and report of pain. Our translational perception of pain and pain-related physical pathology is a challenge. It underscore the point where advanced synergy cross-cut problem-solving approach and allow to be measured by a host of factors that will influence the people's experience and report of pain [30].

The assessment and management of subjective states challenge scientists, professionals and practitioners for centuries. They cannot be observed as individual states, psychological events or experiences. Recognition of competence of traditional disciplines is in modern management issue of translational approach. Models are different, in integrated pain domain has psychology very important role [2, 12, 22].

3.1 Psychological Assessment of People Experiencing Pain

Chronic pain is the model of burdensome disturbance. It is a common problem within the community, and is known to affect different categories of psychological and physiologic health, social conditions and economic wellbeing [1, 13, 20, 42]. People with chronic pain use health services more frequently than the rest of the population [1].

Chronic pain assessment and its impact on physical, emotional, and social functions require multidimensional qualitative tools and health-related quality of life instruments (Table 1.).

Table 1. Pain Assessment Tools [21]**.**

CHEPs – contact heat evoked potentials, CT – computer tomography, EEG – electroencephalography, EMG – electromyography, ENG – electroneurography, ERP – even related potentials, fMRI – functional magnetic resonance imaging, LEPs – laser evoked potentials, MR – magnetic resonance, PET – positron emission tomography.

Clinical examinations ▪ Pain history ▪ Clinical status ▪ Scales ▪ Questionnaires
Physical examination
Instrumental (specific diagnostic) tests ▪ Morphological tests – Static (X-ray, CT, MR, light and electron microscopy) – Functional (PET, fMRI, immunohistochemistry, immunocytology, immunofluorescence and immunoserology, molecular genetic tests) ▪ Neurophysiological procedures – electrophysiological (EMG, ENG, EEG, LEPs, CHEPs) – psychophysiological (ERP- P300) ▪ Psychophysical tests (thermotest, vibrametry, algometry, von Frey test, ...)

It affects all aspect of functioning and often elicits feelings of helplessness and emotional distress, such as depression, anxiety, anger, and frustration. Chronic pain also results in many days lost from work and is often accompanied by inactivity, increasing disability, addiction, alcohol and drug abuse and handicap.

Meaningful assessment of long-lasting pain is therefore very demanding multidimensional task. Its accurate assessment is critical for recognition of alterations, determining the appropriate management and accompany the effectiveness and convincingness of interventions. Regularly assessment of people with pain depends on their thoughts, moods, behaviour, experiences, beliefs and myths of pain [37]. This procedure is comprehensive analysis of the impact of pain on person's life. Multimodal approaches toward relieving pain, person's participation, and improving self-efficacy should be assessed regularly for the presence of pain and for improvement, deterioration, or complications attributable to pain management [38]. His responses on pain and its management are attributable to his acceptance or denial of chronic burden.

3.1.1 Psychological Measurement of Pain

The nature of pain makes objective measurement impossible. Several tools essentially based on pain descriptors have been proposed. The first and most used possibility are self-reported measures. Their quality base on the selection of the most suitable tools for a given situation. Most people with pain reported at least four dimensions of pain experience: pain intensity, pain affect, pain quality and pain location. They could be measured by different measures (Table 2).

The measurement of pain is important to determine pain intensity, quality and duration; to aid in diagnosis; to help decide the choice of therapy; and to evaluate the relative effectiveness of management [38].

Table 2. Psychological measures of pain [39]**.**

Self-reported measures of pain ▪ Self-report scales (verbal rating, numerical rating and visual analogue) ▪ Questionnaires (i.e. McGill Pain Questionnaire) ▪ Comprehensive measures and measures specific to pain beliefs and coping ▪ Psychosocial context in which people with pain functions (role of the couples and families)
Measures of pain not dependent on self-report ▪ The facial expression of pain ▪ Assessment of pain behaviours ▪ Psychophysiological and neuroimaging ▪ Quantification of function ▪ Comprehensive (translational) approach

For centuries pain was acknowledged as purely sensory experience. The crucial affective, motivational and cognitive dimensions were neglected. Generic questionnaires, applicable to any type of pain were needed. According to collected knowledge, many alternative pain pathways from skin to a pain centre in the brain existed. One-to-one relation between the magnitude of an injury and the intensity of pain sensation was inaccurate. Therefore many questionnaires were developed. Most successful tool was the McGill Pain Questionnaire (MPQ) [25] (Figure 1.). This was clearly the biggest step towards progress of clinical tools for assessing the different aspects of the pain experience [3, 41]. The immediate widespread success of the McGill Pain Questionnaire among clinicians was probably related to this

questionnaire being genuinely patient-oriented, through its focus on the language of pain [28]. They became "gold standard" in measurement of the various characteristics of acute and chronic pain. It measure pain characteristic across different pain conditions, was successfully confirmed and used in countless clinical trials and experimental studies.

The length of original MPQ [25] seems to be a limitation, though clinical practice confirmed that it is very useful in wide spectrum of people with pain. Validation of this and both short forms MPQ [4, 26] overcome many limitations. Especially short form MPQ-2 promise new approaches. Its ambitious goal is validating a comprehensive measure of pain quality for use in studies of the epidemiology, natural history, mechanisms and treatment response of both neuropathic and non-neuropathic pain conditions.

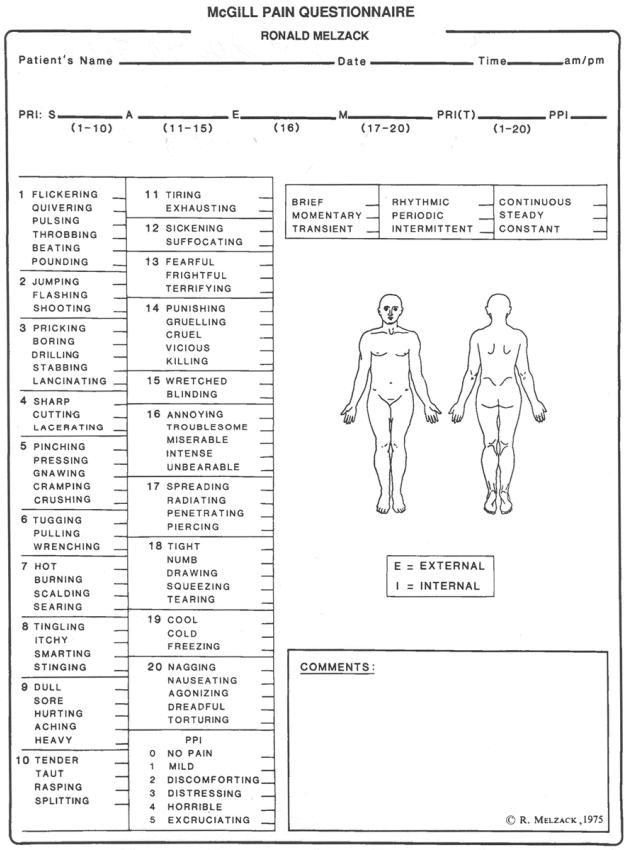

Figure 1. McGill Pain Questionnaire [25]**.**

This extraordinary questionnaire and its variants [4, 24–26] aren't suitable for all populations, therefore special tools are used. Identification, evaluation and determination of effectiveness of pain managements can be a challenge in these and others special populations, i.e. people who are non-verbal, confused, who have intellectual or developmental disabilities etc. They cannot participate in usual clinical approaches and require nurse-reported and observational pain assessment tools.

Those people are not always capable to recognize their own pain, are at risk for inadequate assessment of pain and does not complain if the management is inadequate [15, 33, 34, 40] (Table 3).

Table 3. Determination of pain reported by special population.

Assessment of special populations
▪ in infants, children and adolescents
▪ in older persons
▪ in patients with different diseases and management
▪ in persons with limited ability to communicate
▪ in uniformed persons
▪ in prisoners
▪ …

3.2 Psychological Approaches to Pain Management

The management of pain is an important and demanding domain. Strictly biological approach was prevalent but limited. Extent of complaint and disability reported by many patients could not be explained by the extent of damage or disease [8, 9]. Melzack and Wall [29] opened new perspectives for people with chronic pain. The entire neuroaxes, especially neuromatrix [23, 31] were accepted as cornerstone of pain management. In first successive years psychological characteristic associated with people with chronic pain became central importance and psychologists attempt to isolate them. Chronic pain is a complex concept that cannot be simply broken down into distinct, i.e. physical, psychological, social etc. components. Such factors are viewed as intricately related to the pain perception process. When pain become chronic, burdening factors play an increasingly dominant role in the maintenance of pain behaviour and suffering.

Psychological interventions are a mainstay of modern pain management practice and recommended feature of a modern pain treatment service [6, 10]. They could be alone or combined with a physical or pharmacological treatment; as part of integrated rehabilitation procedure could be important and promising possibility for many people with chronic pain (Table 4.).

Table 4. Psychological approaches to pain management.

Recommended psychological approaches
▪ Acute pain management
▪ Enhancing motivation to change in pain treatment
▪ Operant conditioning with chronic pain
▪ Cognitive-behavioural therapy
▪ Psychodynamic psychotherapy
▪ Biofeedback and relaxation therapy
▪ Hypnosis and imagery
▪ Group therapy
▪ Treating families
▪ Integration of pharmacotherapy with psychological treatment

Statements about specific treatment that are most effective for certain people and under what specific conditions are not determined yet. Psychologists implement them in the management of subjects with pain and can effectively help them to control their pain and live normal life despite pain. They became active participants in the management process and throughout lives.

Transdisciplinary approach is an excellent attempt to bridge domains for seeking creative integrated solutions and proposing a research agenda that advances the methodological and theoretical understanding of what can be, how it can be pursued and what it can contribute. Psychological treatments include many

interventions that are not limited to increased self-management of pain, improved pain-coping resources, reduced pain-related disability, and reduced emotional distress.

4. CONCLUSION

Pain means suffering and burdens as long as humans have existed. To attempt to remedy this suffering and relieve pain, accurate recognition, assessment, measurement and management must occur.

Pain is transdisciplinary problem and disciplinary organisation of scientific knowledge hampers the ability to study, cope with and challenges the solution. This demands action in many domains of science and collaboration in research and education across disciplines.

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KRITIČNA TEORIJA NEVROZNANOSTI

Združevanje kritične teorije družbe s kritično nevroznanostjo

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IZVLEČEK

V svoji predstavitvi se bom osredotočila na pomen družbenointeresnega vpliva na izvajanje nevroznanstvenih raziskav. Poznavanje obsega nevrorevolucije in združevanje *teorij kritične teorije družbe* (filozofije Jürgena Habermasa, Maxa Horkheimerja in Teodorja Adorna z začetka 20. stoletja) s *kritično nevroznanostjo* (mladim, a hitro razvijajočim se pristopom znotraj nevroznanosti, ki kritično pretresa njene temelje in izsledke) bi bilo v bodoče mogoče upoštevati pri načrtovanju in interpretiranju rezultatov raziskav.

KLJUČNE BESEDE

nevroznanost, kritična teorija družbe, kritična nevroznanost, predpostavke, raziskovalni proces, interpretacija

1. UVOD

Antropolog Sunder Rajan se v svoji politični analizi, delu "Biocapital" [10], osredotoči na dva koncepta, ki imata pomembno vlogo pri razvoju znanosti: Življenje in kapital. Življenje, na eni strani, kot ena največjih človekovih vrednot - tudi zadnja točka človekove domišljije, kapital pa, po drugi strani, gonilna sila družbene organizacije, ki predstavlja pomembno strukturno komponento našega delovanja. Ko ju združimo (torej, življenje in kapital), po njegovem mnenju nastane t.i. *biokapital*. Osrednjo točko te združitve vidi v tehnoznanosti. S tem, ko imamo življenje, kapital in tehnoznanost pod eno streho, se drugi dve vozlišči analitične mreže: politika; polje družbenega udejstvovanja, in pa subjektivnost, ki je v nenehni interakciji z drugimi vozlišči v mreži, po njegovem mnenju precej enostavno priključita. Čeprav se njegova študija iz devetdesetih let prejšnjega stoletja navezuje na, v osemdesetih letih vzhajajočo bio-genetsko znanost, pa lahko njegove ugotovitve apliciramo tudi na sedajšnjo nevrorevolucijo in odpremo pomembna vprašanja o vplivu družbenih interesov na znanstveni razvoj.

2. NEVROREVOLUCIJA

Preučevanje možganov je postalo zaščitni znak sodobne družbe. Tu se namreč zgodi presek med fizičnim in psihičnim: subjektivnostjo, zavestjo, agencijo - oz. tistim s čimer se identificiramo kot ljudje. Njihovo raziskovanje in razumevanje v zadnjih nekaj desetletjih predstavlja temeljito prevpraševanje našega pogleda na um, duševnost, zavest in individualno človeškost. Brez dvoma predstavlja nevroznanost eno večjih upanj po novostih, nepričakovanih odkritjih in tehnoloških inovacijah [12]. Kar nekaj avtorjev (Slaby, Cludhury, Rose, Voros, Markič idr.) pa se je začelo spraševati, kaj pravzaprav takšen pritisk lahko pomeni za znanost, ki možgane preučuje, na kakšen način to, da možgani ostajajo simbol za mesto oblikovanja identitete posameznika, vpliva na načrtovanje in izvajanje raziskav, ter tudi, ali lahko z nevroznanstvenimi raziskavami sploh odgovorimo na vprašanja, ki si jih postavljamo glede naše identitete. Označevalec "nevro-" namreč v tem času hitro začne delovati promotorsko, kar pa je lahko nevarno za pretiran vpliv odnosov z javnostmi in potrošniške prakse - torej aspektov kulturne industrije - na prakso raziskovanja. [12]

3. KRITIČNA NEVROZNANOST

Za pravilno vpenjanje rezultatov nevroznanstvenih raziskav v strokovni jezik in družbene konstrukte je nujno potrebno dobro razumevanje konceptualnih, metodoloških in metafizičnih predpostavk, kar je tudi eden od razlogov, da se je začela znotraj nevroznanosti razvijati nova, mlada disciplina: kritična nevroznanost. Ta želi kritično prisostvovati, situirati in izzvati omenjen "nevro-" univerzum in njegove ranolike podpornike in sledilce v- in izven nevroznanstvenega polja [2]. Je širša akademska perspektiva, ki stremi k razumevanju faktorjev in trendov, ki so sooblikovali in pripomorejo k nadaljni fascinaciji nad nevroznanstvenimi tematikami. Zanima jih, kaj je bilo v zadnjih desetih letih, s pomočjo tehničnih in metodoloških inovacij odkrito o funkcioniranju nevroaparata, v primerjavi s tem, kar je bilo potencialno izgubljeno kot posledica tega, da smo možgane označili kot nujni raziskovalni subjekt za vse, kar naj bi bilo človeškega. Jan Slaby, npr., problematizira tudi primere preuranjene aplikacije možganskih

tehnologij v primerih, ko njihova uporaba še ni dovolj raziskana (npr. fMRI kot detektor laži) in ima lahko močne vplive na preiskovanca [2].

4. KRITIČNA TEORIJA DRUŽBE

Pod okriljem Frankfurtskega inštituta za družbene raziskave so na začetku 20. stoletja delovali teoretiki, ki so si prizadevali za sodelovanje med filozofijo in družbenimi vedami – takrat striktno ločenima področjema. V tem smislu so razvili neomarksistični kritični diskurz. Raziskovali so vpliv različnih interesov (kapitala, politike itd.) na različna področja: poznani so predvsem po kritiki popularne kulture in kič umetnosti, za nas pa so tu relevantni predvsem zaradi svojega kritičnega pristopa k znanstvenim praksam. Raymond Geuss v svojem delu *The idea of A Critical Theory* [3] pravi, da kritične teorije ne tekmujejo z ostalimi oblikami znanja, ampak razvijajo svojo smer, pri kateri se posameznik emancipira od socialno induciranih oblik prepričevanja, istočasno pa poskuša razumeti, zakaj ostale oblike znanja prav tako ne privzamejo emancipirane vloge. Tako Max Horkheimer v svojem eseju »Tradicionalna in kritična teorija« [7] razlikuje med dvema tipoma teorije: *tradicionalno*, ki se postavi izven praktičnih, političnih, ekonomskih in socialnih kontekstov, in *kritično*, ki raziskovalca 'vzame v račun' kot del tega, kar je raziskovano, in obenem sprejme dejstvo, da je znanstveno poslanstvo samo še eno od ne-samozadostnih aktivnosti človeka [7]. Pomemben aspekt tradicionalne teorije je distanca do neznanstvenega sveta: tradicionalnih znanstvenikov ne zanimajo praktične posledice ali predpostavke njihove študije, čeprav se zavedajo, da te obstajajo: če se pojavijo v delu tradicionalnega znanstvenika, jih bo - tako Horkheimer - le-ta dodal med dejstva, torej jemal kot samo še en nabor podatkov, ki jih lahko opazuje (in ne spreminja). Kritični teoretik pa po drugi strani ne jemlje v zakup le dejstva, da na njegovo perspektivo močno vplivajo popolnoma praktični interesi, ampak to perspektivo prenese v sam znanstveni vpogled.

Podobno kot Horkheimer pa razmišlja tudi Habermas [4], ki pa se osredotoči na pomembnost emancipcije, torej osamosvojitve znanstvene misli in preučuje vpliv interesov na znanje in kontekst, znotraj katerega se oblikujej nova vedenja. Zaradi »tehnokratske zavesti« (kakor označuje zavračanje racionalnosti izven neinstrumentalnega) ljudje po njegovem mnenju izgubijo svoj obstoj kot bitja, ki »živijo skupaj in diskutirajo zadeve eden z drugim«, saj so obravnavani kot bitja, ki »manipulirajo« [4].

5. KRITIČNA TEORIJA NEVROZNANOSTI

Znanost torej nikoli ne deluje neodvisno od okolja: vedno se odziva na družbene interese v svojem času, poleg tega pa raziskovalci predpostavljajo veliko stvari, od izbire pravilne metodologije pa do efektov, ki jih bo znanost povzročila s svojimi odkritji. Vse te stvari pomembno vplivajo nanjo, in čeprav se kritična teorija zaveda, da jih ni mogoče popolnoma eliminirati, se jih je vsekakor pomembno zavedati. To lahko storimo z interdisciplinarnim kritičnim razmislekom, kar lahko ponudi ravno združevanje kritične teorije družbe in kritične nevroznanosti ter vključevanje njunih ugotovitev v kognitivno znanost. Hartmann [2] trdi, da je kritična teorija nevroznanosti kot taka še v povojih. Njen smoter naj bi bil raziskovanje metodoloških predpostavk nevroznanstvenih raziskav, njihova ocena in prikaz, kako lahko rezultati znanstvenih raziskav spodbujajo socialno represijo. S tem bi bilo mogoče nakazati, kakšno vzročno-posledično vlogo ima kapitalizem pri vzpostavljanju posebnih vezi med znanostjo in svetom onkraj nje. Nenazadnje pa bi kritična teorija nevroznanosti morala postreči z etičnim, političnim, sociološkim in psihološkim znanjem, ki bi omogočilo, da presežemo prej omenjene (predzgodovinske, objektivno nezmotljive) avtoritativne znanstvene diskurze Zato je za ocenjevanje potenciala novega polja na razpotju medicine in humanistike in istočasnega ohranjanja visokih standardov akademske prakse in uvidov, relevantne diskurzivne in disciplinarne tradicije, potrebno konstantno in temeljito prevpraševanje konceptualnih, epistemoloških in institucionalnih predpostavk.

6. ZAKLJUČEK

Pri snovanju raziskav raziskovalci v določenem času na določenem kraju močno vplivamo na potek raziskave, njene rezultate in njihov pomen. Vprašanje pa je, katerih miselnih preskokov se moramo pri izvedbi raziskave zavedati in jih, če je le mogoče, omejiti. Je mogoče pogled teoretikov kritične teorije družbe povezati s pristopom kritične nevroznanosti in katere konceptualne predpostavke nevroznanstvenih raziskav lahko na ta način odkrijemo? Katere predpostavke so vsebinsko tako vprašljive, da so zaradi njih rezultati raziskave neustrezni? Je mogoče miselne preskoke z raziskovanjem omejiti? Na kakšen način diskurz o t. i. »nevrorevoluciji« vpliva na metodološko zasnovo raziskav? In nenazadnje: v kolikšni meri je preširoka interpretacija rezultatov raziskave odgovorna za ustvarjanje medijskega pompa? Na vsa ta vprašanja si bom poskusila odgovoriti v svoji magistrski nalogi.

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Distinct evoked potential for different lexical roles of the same word

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ABSTRACT
Separating between semantic and syntactic aspects of language processing in the brain is a challenge. In an attempt to distinguish between the two, many studies so far have measured responses to semantic or syntactic violations in reading comprehension tasks. However, this methodology may be inadequate in describing semantic and syntactic processing during normal reading, when hardly any violation occurs. In our study, we are thus developing a novel task including syntactically correct sentences without lexical-semantic anomalies, in order to shed light on semantic and syntactic processing during language comprehension, in normal reading. We present results from a behavioural experiment, designed to test and select between two different versions of a task, and results from a pilot ERP study, measuring brain responses to the difference in the syntactic role of the target words.

Categories and Subject Descriptors
I.2.7. [**Artificial Intelligence**]: Natural language processing – language models, language parsing and understanding.

General Terms
Experimentation, Languages, Theory.

Keywords
Language comprehension, syntactic violation, ERPs, normal reading task, noun-plus-noun constructions.

1. INTRODUCTION
Semantic and syntactic aspects of language processing are associated with characteristic electrophysiological responses to language stimuli [6],[14],[15] – see section 2. Many of these studies use reading comprehension tasks, involving stimuli of sentences which contain either a semantic or syntactic violation. The type of violation is used to reveal the syntactic or semantic process in question. However, this methodology offers no insight into how these types of processing are distinguished in normal reading, that is, without violating the syntactic rules or semantic expectations.

In this study, we present a novel task for event-related potentials (ERP) studies which enables distinguishing between semantic and syntactic aspects of language processing in normal reading. In the experimental design, participants are presented with target words which differ by their syntactic role, but have similar semantic content, and are otherwise (e.g., orthographically) identical. For this, we make use of noun-plus-noun (NN) constructions in English, in which the first noun preserves its meaning while changing its position on the syntactic tree, moving from the position of the specifier of a head in a noun phrase (NP), to the head of the NP in a simple sentence without such construction. For example, compare between the word *family* in 'It's a family discount' to the same word in 'It's a family from Sweden'.

We conducted two experiments, a behavioural and an ERP experiment. The behavioural experiment was designed to test the validity of the novel task described below, and it is also used to select pertinent stimuli for the task. We then conducted an ERP pilot study using the task and the stimuli which were selected according to the behavioural experiment. We present here qualitative results from this pilot study.

2. ERP SIGNATURES OF SEMANTIC AND SYNTACTIC LANGUAGE PROCESSING
In order to study the first language (L1) syntactic aspect of language processing, many ERP studies adopted violation paradigms where non-grammatical sentences are compared with correct sentences, which are otherwise similar to the violation stimuli. These studies assume that when all other linguistic variables are held constant, the brain response to the target stimulus, compared to the control stimulus, reflects processes which are related to the grammatical rule in question. The major ERP signatures reported in L1 sentence processing are (for a recent review see [3]):

The early left anterior negativity (ELAN) The ELAN component peaks at around 200ms, with left-anterior distribution, in response to violations of an obligatory phrase structure - see, e.g., [7],[11],[25].

The left anterior negativity (LAN) The LAN component peaks at around 400ms, with left-anterior distribution, in response to morphosyntactic violations such as grammatical agreement violations, tense-marking violations and case-marking violations - see, e.g., [17],[17],[18].

N400 The N400 component peaks at around 400ms, with centro-posterior distribution, in response to lexical-semantic anomalies – see, e.g., [5],[10],[12],[13],[26].

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P600 The P600 component peaks at around 600ms, with posterior distribution, in response to various violations of syntactic and morphosyntactic features, thematic-rule structure violations, temporary ambiguities, semantic anomalies, and long-distance dependencies - see, e.g., [4],[6],[17],[18],[27].

3. FIRST LANGUAGE (L1) - SECOND LANGUAGE (L2) SIMILARITY

In this study, we tested native Italian speakers, with high proficiency in English, on a task in English. The brain responses of these participants were recorded in an ERP design. Previous studies have found that participants with high proficiency in L2 have similar brain responses compared to L1 speakers. Several ERP experiments have been conducted on L2 speakers presenting sentences with morphosyntactic and phrase structure violations [21]. Results show that low-proficiency L2 speakers did not show a LAN effect for morphosyntactic violations with a delayed P600 for both types of violations [19] as compared to natives. However, participants with high proficiency showed similar response to that observed with L1 controls. The authors concluded that, at high-enough L2 proficiency levels, an L1-like brain response can be observed, reflecting early automatic parsing processes followed by late processes of reanalysis and repair.

4. NOUN-PLUS-NOUN (NN) CONSTRUCTIONS IN ENGLISH

NN constructions are composite nominals in which both the head and the attributive dependent(s) are nouns [8], e.g., *family discount, bus driver*. These types of NNs are a common type of constructions in the English language. However, their role in its grammar is nevertheless still an ongoing debate among linguists, as some classify them as a phrase, originating in the syntax [9], while the others claim them as compounds, originating in the lexicon [9]. Another group of studies claims they can belong to both categories [19]. Furthermore, Giegerich [9] also distinguishes between the fore-stressed and end-stressed NNs, assigning them into two different origins. Avoiding this debate, and in order to keep a homogeneous set of stimuli in the experiment, we therefore chose NNs with a fore-stress only.

5. METHODS

5.1 Participants

The participants of this study are native Italian speakers with high proficiency of English. All the participants are between 18 and 40 years of age and right-handed. In the behavioural experiment, 10 participants have taken part. In the ongoing ERP experiment, 8 participants have participated so far, who did not take part in the behavioural experiment.

5.2 Stimuli

40 syntactically and semantically correct pairs of English sentences, presented in form of quiz questions. In the behavioural experiment, the beginnings of the answers to 40 pairs of them were presented in *audio-only* format (version 1) and 40 pairs of them in *audio+text* format (version 2)[1]. Following the results of this part of the study, only version 2 was included in the ERP experiment. Both experiments consisted of 10 blocks, each block containing 40 quiz questions. Four possible answers were given for each question (see fig. 1).

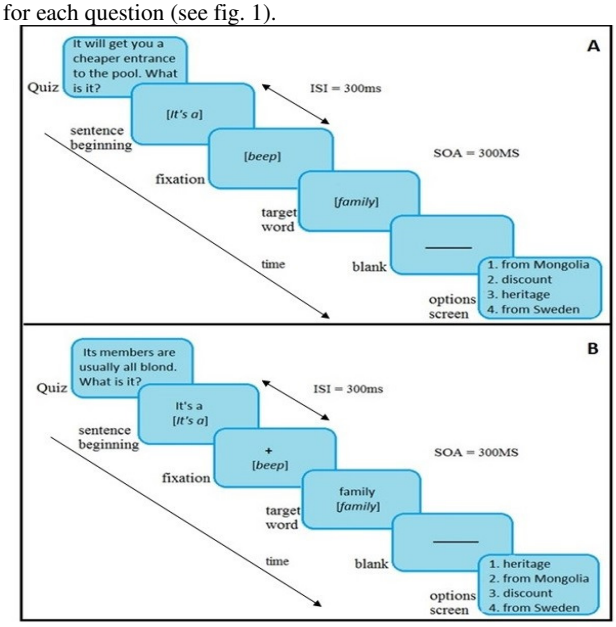

Figure 1. Two versions of the novel task *audio-only* (A) and *audio+text* (B).

5.3 Design and procedure

We present a novel task for ERP studies which enables to distinguish between semantic and syntactic aspects of language processing in normal reading. To do so, participants are presented with target words which differ by their syntactic role but have similar semantic content and are orthographically identical. We make use of NN constructions in English to contrast between, e.g., the word *family* in

(S1) It's a family discount. (*NN condition*)

(S2) It's a family from Sweden. (*Simple noun condition*)

However, such a comparison is only possible if the syntactic expectation of the participant in (S1) is the desired one while reading the target-word. For example, such a comparison would fail if the participant comprehends *family* in (S1) as a pre-head only after having completed and reanalysed the sentence. We therefore manipulate the syntactic expectation of the participant by preceding the sentence with a quiz question, the answer to which requires the desired syntactic role only. Continuing with the above example, we precede (S1) with the following quiz question (see fig. 1 for the complete experimental design):

(Q): It will get you a cheaper entrance to the pool. What is it?

The quiz is then followed by a beginning of an answer: (A) 'It's a family ____'.

Note that whether the participant knows the correct answer to the above quiz question is unimportant. Even without knowing the correct answer to (Q), we hypothesised that one would expect the answer (A) to the question in (Q) to end with a noun, thus reading *family* as an adjective. This kind of expectations are also enhanced after the practice block. Note also, that data analysis focuses on the time during which the participant reads the target word (e.g., *family*), before she is asked to complete the sentence. We therefore regard it as normal reading, and are not concerned with other processes that may follow. Importantly, while creating syntactic expectation, the preceding

[1] A third version of the task, *text-only*, was previously used with partially overlapping stimuli in a preliminary study [16].

quiz question must not have created semantic expectation to the target word. Therefore, all words in the quiz questions were made sure not to be semantically related to the target word in their answers (as can be assessed with Latent Semantic Analysis). For example, no word in (Q) semantically primes the target-word in (A). An additional benefit to this manipulation is that it enhances the engagement of the participants in the task, by challenging them with quiz questions.

In order to test the validity of the design and to select between two versions of the task, we ran a behavioural experiment. Based on the results, described below, we made this choice before engaging in the main, ERP experiment, described in detail in the following two subsections.

5.4 EEG recording

The EEG is continuously recorded using the ActiveTwo BioSemi system (BioSemi V.O.F., Amsterdam, Netherlands) with 128 channels covering the entire scalp. EEG signals are sampled at 512 Hz with band-pass filters set at 0.1–100 Hz.

5.5 Data analysis

Acquired data is analysed using EEGLAB, open source MATLAB (The Matworks, Natick, MA) toolbox for EEG processing. Data is first high-pass filtered at 0.15 Hz and low-pass filtered at 30Hz, and re-referenced. Next, follows an extraction of the epochs of the two conditions. In both epoch sets, the answer of the participants are divided into three groups: the correct answer (e.g., 'discount' in (Q)); the semi-correct answer (e.g., 'heritage' in (Q)), which is syntactically correct, suggesting that the participant comprehended the target word in the desired syntactic role; and wrong answers (e.g., 'from Sweden' and 'from Mongolia' in (Q)). The answers are counterbalanced over conditions such that, for example, 'from Sweden' is the correct answer, 'from Mongolia' the semi-correct, and 'heritage' and 'discount' are the wrong answers in the second condition. All the wrong answers are omitted and only the correct and semi-correct answers are included in the analysis. The data is pre-processed and artefacts are omitted using independent component analysis (ICA).

6. RESULTS

6.1 Behavioural experiment

We tested whether quiz questions can induce the desired syntactic expectation when participants read the target sentence. Fig. 2 shows that reaction times are on average faster with the NN construction, and faster in the *audio+text* version of the task.

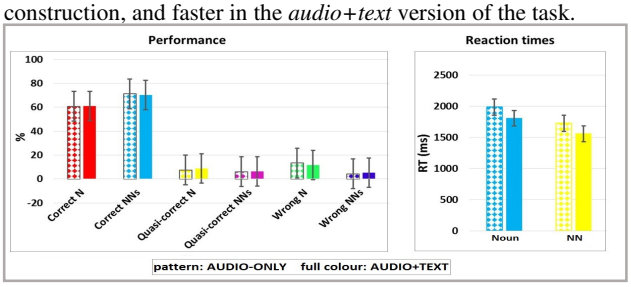

Figure 2. Results of the behavioural experiment.

We ran a two-way ANOVA with two different syntactic roles (nouns and NNs) and two different presentation modalities (*audio- only* and *audio+text*). Results confirm that the reaction times with the NNs are significantly faster ($F(1.39) = 23.69$, $p < .00$), and indicate a trend towards faster reaction times in the *audio+text* version ($F(1.39) = 3.173$, $p = .083$). A significant effect of syntactic roles of stimuli was also shown by a post hoc analysis, according to which the faster times in the *audio+text* version in comparison to audio only version, when dealing with nouns, reach significance. All other post hocs were not significant.

Further, the faster performance of the participants when presented with the *audio+text* input indicates that this may be the most appropriate version of the task. We were thus able to reach our goal in this part of the experiment, in making a principled choice between the two versions of the task before engaging in the ERP experiment.

6.2 ERP experiment

Since the ERP experiment is still ongoing, we present results from our pilot study, which reveal different ERP signatures for the two conditions. Fig. 3 shows this result for a single subject and electrode (D15) in the period between 330 and 400ms after blank onset.

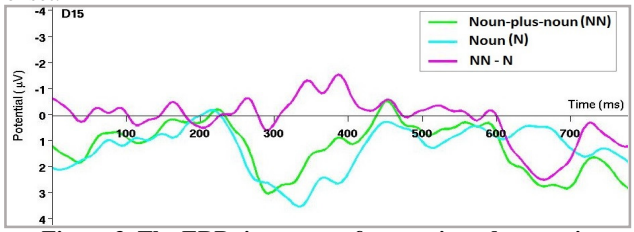

Figure 3. The ERP signatures of syntactic and semantic processing, for an arbitrarily chosen participant.

The behavioural results of this experiment confirmed the results of the behavioural experiment, revealing that subject performance is better in the NN conditions (fig. 4).

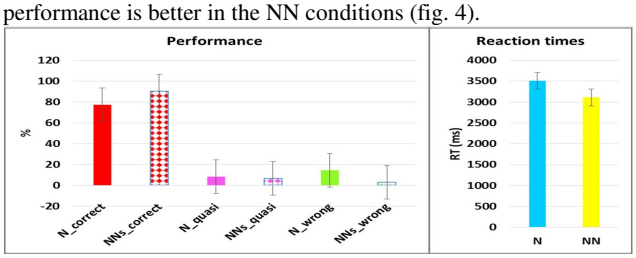

Figure 4. Behavioural results of the ERP experiment.

7. SUMMARY AND DISCUSSION

In this study, we present a novel paradigm to disentangle the syntactic aspect of language processing from its semantic aspect. The paradigm avoids the use of syntactic violations, and focuses on normal reading of correct sentences. We make use of NN constructions in English to contrast between two conditions which differ by their syntactic aspect only. In order to manipulate the syntactic expectation of the participant before reading the target word, we use quiz questions, such that the answer to the questions allows only one possible syntactic role to the target word. We tested the method of manipulating the syntactic expectations of the participants in a behavioural experiment.

Behavioural results indicate that the paradigm is easier in the NN condition, but is reasonably effective for both conditions for the selected group of stimuli. Following the behavioural experiment, we ran an ERP pilot study using the novel paradigm and selected version of the task. Albeit only qualitative, pilot results are showing promising disclosure of different ERP signatures for the two conditions, opening a new window into syntactic processing during language comprehension in normal reading. We believe that it may provide a way to relate observable signals in the human brain to hypothesised

mechanisms in models of latching dynamics [23],[24], in particular at the transition between words [21].

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Medical Approach to Pain as Transdisciplinary Phenomenon

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ABSTRACT
Pain is very demanding research, professional and practical domain. Due to ubiquitous nature of unpleasant experience and unacceptable proportion of people with pain there is continuing need for adequately trained professionals. Future opportunity and hope will be translational management of common symptom/syndrome/disease that is too often underdiagnosed, undertreated and associated with suffering, disability, impaired quality of life, and increased cost. Pain begins with simple event and seems to be easily interpretable but only coordinated transdisciplinarities will give us comprehensive outcomes.

General Terms
Management, Measurement, Documentation, Experimentation, Human Factors, Standardization, Theory, Verification.

Keywords
Critical research, Disciplinarities, Pain, Physiology, Problem-solving research, Psychology, Psychophysics, Sensation, Translational approach

1. INTRODUCTION
Pain as a subjective phenomenon was, is and for now remains one of the great unanswered challenges for people with this troublesome experience and their significant others. It influences all involved people, their physiological and psychological processes, and by the row of informations challenges equilibration of systems. These extremely dynamic processes involve continuous massive interactions among complex ascending, descending, transversing, reverberating or differently interconnected systems.

Exclusively biological Descartes' concept propose that pain is produced by a direct, straight-through transmission system from injured tissues in the body to a pain centre in the brain [34]. It goes through different understandings and develops to acceptance of pain as processing of neural signals. The 'neurosignature' output of the neuromatrix - patterns of nerve impulses of varying temporal and spatial dimensions - enters an active nervous system [33]. It acts on the neuromatrix programs and ends as the concept of pain as a multidimensional experience, modulated by multiple influences [35]. This is for now the most comprehensive theory of pain mechanisms.

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2. PHENOMENON OF PAIN
Pain is very important issue and is of utmost concern for life. This subjective state range from i.e. mere unpleasantness to extreme physical agony, from the feeling of sadness to extreme cognitive exhaustion, from fight to desolation accompanying an episode of major depression. Despite neurologists, neurophysiologists, psychophysiologists, psychophysicists and pain specialists (algologists), that were at the beginning most influential on field of sensory achievements, reached enormous advance, this multidimensional phenomenon with various faces have required, requires and will require more than coordinated multidirectional intra-, multi-, cross- and interdisciplinary approaches, transdisciplinary thinking and unusual translational working [27, 44].

In pain domain remain despite the above-mentioned challenges many obstacles. Clinically meaningful development of a systematic, sensitive, reproducible and comprehensive examination tool for a standardized and validated examination of sensory phenomena is much awaiting. It has to be sufficiently rapid and simple to be used routinely in the setting of an active clinical practice. Because of the subjective nature of pain experiences seem such valuable discoveries like an impossible achievement. This important goal is exciting challenge of transdisciplinary research groups.

One of most demanding and usually doubtful task is recognition of sensory information. This process includes somatosensory functions, sensation, perception and recognition (Table 1).

Table 1. Sensation, perception and recognition [31, 32]**.**

sensation	initiation of physiological processes by sensory stimuli (i.e. prick)
perception	awareness and cognitive (conscious, mental) interpretation of sensory stimulus (i.e. we are aware that something has happened, simultaneously with sensation)
recognition	cognitive ascertaining of sensory stimulus

Interpretation of sensory perception is not equivocal neither simple task, assigned to entire neuroaxis with unique physiologic properties and relevant psychical attributes. Sensation is the process of accepting the environment, meanwhile perception is

the process of attaining awareness or understanding of sensory information. Both are prerequisite for experience, the final conscious result of incoming stimuli [11, 17, 51]. For their correct interpretation the process of different somatosensory stimuli (touch, proprioception, vibration, warmth, cold and different types of pain) is enabled exclusively by the plastic reorganisation of neuromatrices [4, 47].

Modern investigations of pain and other somatosensations have been facilitated by better and universally agreed definitions than existed in the past, by advances in experimental and clinical techniques and by combining research on the diverse fields of knowledge.

3. QUANTITATIVE PSYCHOPHYSICAL ASSESSMENT OF PAIN

Our first steps in the field of pain and other somatic sensations were very cautious. Like pioneers of such crossdisciplinary studies (branches of experimental psychology and neurophysiology) at the University Institute of Clinical Neurophysiology (University Medical Centre, Ljubljana) and generally in Slovenia, SE Europe and wider we studied effects of varied physical stimuli on sensory perceptions. Professors Tine Prevec and Miro Denišlič gave us our first training in the psychophysical and methodically related handling of neurological problems. One of influential methods in pain research and practice is assessment of reaction to stimulus-evoked pain in a systematic and reproducible fashion. In clinical conditions it bases on determination of self-reported perceptions elicited in response to predetermined sensory stimuli. Our work is conceived on Marstock method [12] by commercially available computerized quantitative sensory testing (QST) devices. They have been designed to measure thermal specific and thermal pain sensibility.

Psychophysical testing is performed on the patient's skin. Perception thresholds for thermal specific and thermal pain sensations (warm, cold, cold pain and heat pain) are measured by a thermotest device. Stimulator that produce natural stimuli is technically thermode (thermal probe) with well-defined size, which based on Peltier effect. It creates a temperature gradient by the passage of an electric current between the upper and lower stimulator surfaces. We employ experimental thermal stimuli that can be objectively measured; their rise or fall depends on the direction and the intensity of the current flow through the Peltier device.

In our studies of somatosensation temperature perception was determined as the warm and cold thresholds, and as warm-cold difference limen, the difference between the warm and cold thresholds. The pain perception was determined as the heat pain and cold pain thresholds. Testing subjects indicate the detected stimulus (absolute threshold) [14] by pressing a button, when the respective thresholds are reached.

Cold and warm detection thresholds, warm-cold difference limen, cold pain thresholds, and heat pain thresholds (in that order) are recorded. Thresholds are calculated as the average of four (cold and warm sensation) and three (cold and heat pain) successive measurements with interstimulus interval of 4 and 6 s, respectively. All measurements of a given perception are completed before testing the next perception. To protect the skin from possible thermal injury, the increase and decrease of the thermode temperature is limited to 50° C and 0° C, respectively.

We performed initial, time consuming laboratory testing by Thermotest (Somedic AB, Stockholm, Sweden). Enthusiastic preliminary observations gave us our first practical experience and led us to a real delight of research. The first published results [29, 30] encouraged us to stay on our own way of studying sensation and perception. Official application of thermal specific and thermal pain assessment is mainly limited on confirmation of clinically suspected abnormalities of sensations [1, 2, 18, 20, 39, 48].

Our laboratory instrumental determination of neurological patients was later in the clinical or research setting carried by the NeuroSensory Analyzer (Medoc Ltd., Ramat Yishai, Israel) [7–9]. Quantitative Sensory Testing is officially represented as a valuable method for diagnosing peripheral nervous system disorders, including chronic pain and pain related to various diseases [1, 2, 26, 40, 49, 50]. The method is usually introduced as intradisciplinary, but modern approaches to sensory perception need to make real progress. Objective pain-assessment tools for subjective phenomenon is a challenge of translational sensitivity research [27]. We use it for holistic determination of sensitivity, i.e. whether the subject can detect a stimulus, identify it, differentiate between it and another stimulus, or describe the magnitude or nature of this difference [14, 41, unpublished results].

4. INTRADISCIPLINARY APPROACH

Quantitative thermal specific and thermal pain sensory testing is a fairly sensitive method for detection of neurological dysfunctions especially in patients with normal routine electrophysiological studies.

Sensitivity is highly subjective and absolute thresholds vary with different variables [19, 29, 30]. For QST results to be medically useful, normal values with considerable interindividual variation, documented in previous studies, should be corrected for them. Additionally, there always remains bias because the results of QST have been shown to be additionally highly dependent on receptor's physiological properties, the instruments and their corresponding methodologies [5, unpublished results]. Additionally, integrated research studies and problem solving translational outcomes are presented [5, 6, 13, 40, 46, 50].

4.1 Limitations of QST

This method is very subjective and usually used only for confirmation of clinically presumed abnormalities. Some reasons for insufficient use of these methods are lack of normative values, standardisation of methods and of a "gold standard" for the presence of sensory dysfunction [40, 46]. Additionally, while most neurological studies are intradisciplinary (work within a single discipline – i.e. neurology), our studies guide us to cross-, multi-, inter- and transdisciplinary domain. We established that most basic principles cross different approaches and focus on integrated complex problem solving by crossing disciplinary boundaries.

5. ACROSS THE DISCIPLINARY BOUNDARIES

The processing of biological stimuli, touch, proprioception, vibration, pain, warmth and cold, is enabled by the somatosensory nervous system [10, 24]. Sensation and perception elicit the

experience, prerequisite for cognitive processing of incoming stimuli [11, 17].

5.1 Somatosensory perception changes

For a long time the somatosensory nervous system was tested solely at the bedside. Simple hand-held devices were used and decisions were based on the subjects' feedback reporting [43]. During the past 40 years, more sophisticated and accurate instruments for the assessment of perception have been developed [12, 16, 23, 28, 37, 41]. Psychophysical examinations are used to determine sensory characteristics of different neurological patients.

It is well known that patients with peripheral and / or central sensory alterations might describe their perceptions in different terms. Sensibility is, namely, highly subjective to the individual receiving a stimulus. Stimuli evoke different responses, depending on their physical characteristics, on the individuals' cognitive system and human integrity [24]. Sensibility in healthy people is relatively well known, pathological alterations are broadly studied.

Sensory alterations of any type - especially pain - affect the general functioning and are the most frequent reason for physician's consultation in the developed world [3, 21]. They are the major symptom in many medical conditions and significantly interfere with a person's quality of life. Diagnosis is based on symptoms and signs, considering duration, intensity, type, source and location of impairments, and on additional factors.

In our studies transdisciplinar, transprofessional, comprehensive and problem oriented assessment of sensory alterations were used. Peripherally and / or centrally caused thermal specific and thermal pain sensations were elicited psychophysically by thermal specific and thermal pain thresholds determination. A psychophysically identified / identifiable recognition symptoms and signs of somatosensory perception changes were transdisciplinary understand, accepted, described and divided into classes (unpublished results).

5.1.1 Methods

For the assessment of thermal specific and thermal pain sensibility the MEDOC (Medoc Ltd., Ramat Yishai, Israel) and SOMEDIC (Somedic AB, Stockholm, Sweden) Thermotest apparatuses were used. Always the same sequence of thresholds determination (cold and warm specific thresholds, warm-cold difference limen, cold pain and heat pain thresholds), and the same thermode with well-defined size was used (3 x 3 cm by Medoc and 2.5 x 5 cm by SOMEDIC). Quantitative, qualitative, spatial and time / temporal changes according to Kandel [24] were analysed. Appropriate test sites were chosen between normatively defined areas: face, thenar, medial surface of the upper - and forearm, lateral mammary, lateral umbilical, anterior thigh and lateral leg region and lateral aspect of the dorsum of the foot bilaterally.

In volunteers, cold, warm, cold pain and heat pain in normative limits were determined (see Figure 1).

In patients with neurological dysfunctions the case history with special reference to the diseases connected to neurological dysfunctions was taken. Clinically detectable somatosensory perception changes [25, 36, 38, 45] were followed by the interview and standardized clinical bedside sensory examination.

The operating temperature range was set at 0 - 50° C and the reference temperature of the thermode at 32° C by Medoc, and at 10 - 50° C and the reference temperature of the thermode at 30° C by SOMEDIC.

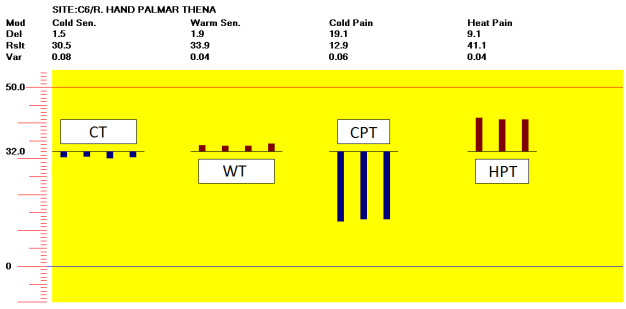

Figure 1. Thermal specific and thermal pain sensitivity expressed as thresholds determined by a Medoc NeuroSensory Analyzer. CT – cold threshold, CPT - cold pain threshold, HPT - heat pain threshold, WT - warm threshold.

According to protocol always the same rates of the temperature change was used [50]. With Medoc the rate of the temperature change were 1° C/s for warm and cold threshold and 1.5° C/s for the cold and heat pain thresholds determination. With SOMEDIC the rate of the temperature change was 0.1° C/s for warm and cold threshold (0.04° C/s on face). For the cold and heat pain thresholds determination the change was 1° C/s.

Prior to the evaluation of thermal sensibility, the skin temperature of each body region was measured by contact thermometer. Temperature change was read off with an accuracy of 0.2° C. Measurements were made in a silent, closed room with an ambient temperature of 22±2° C.

Informed consent was obtained from all subjects according to the Declaration of Helsinki and Tokyo. The studies was approved by the Republic of Slovenia National Medical Ethics Committee.

Our work academically bridges cross-, multi- and interdisciplinary framework, but integrated complex problem solving by crossing disciplinary boundaries within academic and clinical disciplines is even more difficult and demanding to achieve.

The pain as subjective phenomenon cannot be observed without psychological knowledge. Multi- and interdisciplinary approach was promising but the person with pain need health provider with universal understanding. In our work we integrate knowledge, methods and approaches from very diverse domains and create a holistic comprehension.

In promoting a holistic perspective, transdisciplinarity requires considerable effort of engaged researchers. Their research have to open up alternative ways of thinking. In the future, for seeking creative solutions to complex challenges translational view will be obligatory.

6. TRANSLATIONAL APPROACH

Integrated (translational) knowledge is the outcome of integrated studies. Profound changes in disciplinary organisation of scientific knowledge demand transprofessional approaches to advancing theory and methodology. Changed research, professional and practical concepts create synergistic understandings of and answers for complex challenges [22].

Scientific understanding, cross-cutting critical and problem-solving approach, and new synergies across integrated theories led us to complex creating of new knowledge [52].

7. CONCLUSION

Pain is one of the human somatic sensations and a multidimensional sensorial as well as psychical conscious phenomenon. It is a complex sensation, strongly modulated by cognitive influences, and understanding the underlying mechanisms in patients remains a challenge. This common symptom/syndrome/disease is often underdiagnosed, undertreated and associated with suffering, disability, impaired quality of life, and increased cost. As constellation of specific symptoms and signs with multiple potential underlying aetiologies requires integrated research studies, accurate complementary history, examination, transdisciplinary and translationary comprehension.

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PHARMACEUTICAL COGNITIVE ENHANCEMENT: A QUESTION OF PHARMACOLOGY, NEUROETHICS, REGULATION OR PERSONAL CHOICE?

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ABSTRACT

As the trend of using prescription pharmaceuticals to enhance cognitive abilities among healthy adults has increasingly come to the attention of scientists, academics, journalists and pundits over the last decade, much has been written and said about its neurophysiological effects, ethics, usage, as well as the sociopolitical implications. Still, few of the studies showed consistent or significant enhancement effects among healthy subjects. Recently, an overview article of 24 robust studies on the enhancement effects of modafinil on healthy adults concluded that the drug shows consistent enhancement of attention, executive functions and learning in healthy subjects without significant adverse side effects. The first part of the paper provides a brief look at the concept of pharmaceutical cognitive enhancement (PCE) and of some of the effects of popular PCE drugs, finally focusing on modafinil as an apparently efficient and safe cognitive enhancer. The second part provides a brief overview of the public policy recommendations given in the scientific and expert literature on dealing with the trend of PCE use in light of the existence of efficient and safe cognitive enhancers. As PCE becomes increasingly tangible and popular, this is an issue that modern societies will sooner or later have to confront in a rational and informed manner.

Key words: PCE, pharmaceutical cognitive enhancement, neuroenhancement, regulation, modafinil, Provigil, attention, psychopharmaceuticals, neuroethics

1 PCE AND PHARMACOLOGY

Pharmaceutical cognitive enhancement (PCE) or neuroenhancement can be described as the use of certain pharmaceutical prescription drugs by healthy individuals, not afflicted by cognition-related dysfunctions, disabilities or diseases, with the aim of increasing cognitive abilities that are already in the healthy, normal or average range. The cognitive abilities in question usually include perception, short- and long-term memory, attention respectively focus, motor capabilities, language, visual and spatial skills, and executive functions such as decision-making, planning and problem-solving [1-3]. The most commonly used prescription pharmaceuticals include methylphenidate in products such as Ritalin and Concerta, amphetamine salts in products such as Adderall, and modafinil in products such Vigil and Provigil [4]. Ritalin and Adderall are most commonly prescribed for attention-deficit and hyperactivity disorder, while modafinil is prescribed for the treatment of narcolepsy. For the purposes of PCE, such drugs are usually obtained through the internet, from third persons or from a doctor either through an off-label prescription or by simulating disease symptoms [5]. Although some other psychopharmaceuticals such as propranolol [6], atomoxetine [7] and various cholinesterase inhibitors, that is drugs for the treatment of dementias, such as donepezil in products like Aricept [8], have also been occasionally discussed as potential PCE substances, the three previously mentioned pharmaceuticals represent the most widely used and investigated pharmaceutical cognitive enhancers.

Pharmacological studies with healthy subjects have shown that methylphenidate and amphetamines had small but significant enhancement effects on inhibitory control and short-term episodic memory [9], produced improvements in declarative memory and enhanced the consolidation of memories, while positive effects on the executive functions were found in at least some subjects [10]. Methylphenidate also appeared to improve performance in novel tasks and attention-based tasks, and reduced planning latency in more complex tasks [11]. Modafinil enhanced the enjoyment and performance in tasks connected with spatial working memory, planning and decision making, as well as visual pattern recognition memory following delay [12]. It also improved reaction time, logical reasoning and problem-solving. [11]. Further, it improved attention in well-rested individuals, while maintaining wakefulness, memory and executive functions to a significant degree in sleep deprived individuals as compared to a placebo [13]. Generally all three substances exhibited various improvements in levels of attention in healthy test subjects [11].

While the range and scope of their enhancing effects in healthy individuals have been the subject of criticism and debate, often connected with methodological problems and other shortcomings of the studies in question, these psychopharmacological agents do seem to have some tangible effects on the cognition of at least some healthy individuals, even though the enhancing effects often seem to be small and inconsistent.

Despite the uncertainties and previous doubts about the existence of "true pharmaceutical cognitive enhancers", much has been written about the (neuro)ethics of PCE, as well as about their potential ethical, legal and societal implications. This was often justified with the rationale that some supposed pharmacological enhancers are already in (increasing) use among specific populations and that sooner or later genuine PCE substances will be developed. Thus, it was argued, it is best to lay the groundwork regarding possible individual and public policy approaches towards it in advance.

The main "practical" aspects regarding future use and potential regulation of PCE hinges on whether there already exist any genuine pharmaceutical cognitive enhancers, that is, psychopharmacological substances that are effective, safe and possess relatively few and non-serious side effects [14]. As has been noted above, the cognition-enhancing effectiveness of amphetamines and methylphenidate has been low to moderate and varying from group to group and from study to study. Amphetamines have been shown to carry some risk of addiction and increased blood pressure, while methylphenidate showed a low risk of addiction, and generally benign side effects such as slightly increased heart rate, along with some complaints of headache, anxiety, nervousness, dizziness, drowsiness and insomnia [13].

The cognitive enhancement effects of modafinil however, have recently been the subject of an extensive meta-analysis that encompassed 24 robust studies conducted between 1990 and on 2014 on healthy non-sleep deprived adults. Published in The Journal of the European College of Neuropsychopharmacology, the article concluded that modafinil appears to consistently engender enhancement of attention, executive functions and learning in healthy non-sleep deprived subjects, without any observed preponderances for side effects or mood changes [15].

In this light, we can assume that the trend of PCE use among the healthy will most probably continue and increase as far as modafinil is concerned. Although the prevalence and the supposedly increasing use of PCE among a growing number of diverse populations has also been subject to criticism and more thorough empirical investigation [16, 17], indications of increasing PCE use of modafinil are evident, spurred probably not least through having received such widespread scientific and popular attention. There are an increasing number of discussions and reports in various nootropics, biohacking and neuroenhancement self-experimentation online forums, and modafinil is available for order online through an increasing number of vendors.

Given that pharmacology has provided at least a tentative answer on the tenability of true pharmaceutical cognitive enhancers which seems to be affirmative for the case of modafinil, this seems like a prudent time to provide a brief and general overview of the public policy recommendations that were produced over the last decade on the topic of how to address PCE use among the healthy.

2 REGULATION OF PCE

If modafinil is deemed or at least perceived as having been scientifically validated as an effective and safe cognitive enhancer with only benign side effects, we can expect that its future use among healthy adults will likely increase even further. Eventually we will arrive at a point where modern societies will have to approach the use of PCE in a rational and progressive manner. What follows is a brief outline of a continuum of public policy recommendations regarding PCE use among healthy adults that was first introduced in a previous article [17], synthesizing the recommendations that have been produced in the scientific literature and among ethics experts in some national ethics advisory bodies.

The continuum of recommendations for addressing PCE use can be seen as stretching from a laissez-faire approach with no or only minimal regulation at the one extreme, to a relinquishment or ban approach at the other extreme. The former states that market demand and individual liberty should drive the trend and that it will work much more efficiently than government regulation in reaping the benefits and preventing the risks, emphasizing a crucial role for individual autonomy and personal choice in deciding to use or not to use enhancers on an individual basis. The latter holds that the use of PCE entails threats to human dignity, meaning, relationships, societal structures and cherished values, and should therefore be either voluntarily abandoned or prohibited through regulation [18-20]. Especially in the case of wide prohibitions it is easy to imagine how black markets with substances of unproven quality and purity would rapidly proliferate, although the issue of indirect coercion and soft pressures in order to stay competitive in the workplace and in private life is by no means resolved through a laissez-faire approach.

The two approaches between both extremes would be a reasoned pro-PCE approach and a reasoned PCE-restrictive approach, both situated inside a suitable regulatory framework [1-3, 20-29].

The first (reasoned pro-PCE approch) emphasizes the need to respect and safeguard individual decision-making autonomy regarding PCE use, assure the safe and responsible use of PCE through pharmaceutical regulatory mechanisms, and the need to expand research to include long-term PCE use in everyday life, and ensure that it is integrated into existing laws and norms through deliberation with various experts, stakeholders and the public. PCE drugs should be obtainable as part of the private market, but subject to professional medical standards. While employers should not require their employees to take enhancement drugs, they should allow

them to do so voluntarily. As competent adults should be free to use or not to use PCE, it is important to provide access to reliable data on safety and efficacy, which could entail education to increase public understanding of the risks and benefits, as well as alternatives to PCE, and a wider examination of the social values and pressures that make it attractive. Such an approach might also require a model similar to the medical risk assessment system, where the user would weigh the risks and benefits, based on professional medical advice.

Regarding the second (reasoned PCE-restrictive approach), it emphasizes that PCE might, in addition to individual and societal benefits, also have negative societal impacts, especially in the form of coercion and changing social norms. In this regard, the approach might try to influence the conditions under which enhancement could take place. This might involve restricting the use of PCE to certain professions and situations, which would require the participation of relevant professional organizations in the formulation of guidelines for their members regarding PCE. Such organizations would include physicians, who already act as gatekeepers, and place limits on certain uses through professional standards, educators and human resource managers who could protect and advise workers on the use in specific situations and for specific goals, but also labor and professional organizations for those occupations that might be warranted to use PCE in the workplace.

Depending on the stance towards widespread societal use of PCE, monitoring access and promoting social equality might entail either restrictions on general availability through the private market or some type of subsidy or public health access for those who might be most afflicted by increasing cognitive inequalities if PCE drugs are available commercially.

3 CONCLUSION

As is hinted at by the brief and of necessity simplified outline of public policy options above, the pharmacological validation of modafinil as a true cognitive enhancer will not necessarily dispense with the need for a public debate and an eventual public policy approach to dealing with PCE use. While many of the (neuro)ethical, legal and societal aspects have been extensively discussed in the scientific literature and among experts, as to date there has been little deliberation among policymakers and political-decision makers, and practically no public debate on the many extant issues of dealing with PCE use. Possibly, the new overview study on modafinil and the latter's increasing use, along with increased media attention, will have a positive impact in this regard, hopefully in the direction of rational discussions. Also, further research still needs to be performed. While modafinil appears to be moderately effective and generally safe as far as short-term usage is concerned, the effects of long-term and chronic use are still largely unknown, as is the extent of its enhancing effects outside of controlled settings. The modafinil meta-study also provides suggestions in this regard. Until further progress is made in the public policy arena on this issue, personal choice to enhance or not enhance one's cognitive capabilities with modafinil will indeed remain the deciding factor, at least for those that have access to the relevant information and sources of the PCE drug.

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Individual differences in reasoning

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ABSTRACT
The Mental Models Theory and The Mental Logic Theory, two famous theories of human reasoning, are commonly perceived as disjunctive theories. In this work we try to examine possibilities of their coexistence with respect of individual differences between reasoners, incorporating simplified versions of existing theories as possible strategies of reasoning. Spatial representation of information corresponds to the Mental Model Theory, while verbal (propositional) strategy can be connected to the Mental Logic Theory.

Categories and Subject Descriptors
The ACM Computing Classification Scheme is not fully applicable for this submission, but it can be partly connected with

I.2 [**Artificial Intelligence**] I.2.0 General - *Philosophical foundations*; I.2.3 Deduction and Theorem Proving - *Deduction (e.g., natural, rule-based)*; I.2.8 Problem Solving, Control Methods, and Search - *Heuristic methods*.

General Terms
Measurement, Theory

Keywords
Reasoning, individual differences, mental models, mental logic.

1. INTRODUCTION
Individuals with no previous knowledge in formal logic are able to make deductive inferences. For example, for given arguments:

If I have 1 euro in my pocket, I can buy a coffee.

I have 1 euro in my pocket.

they draw the conclusion:

I can by a coffee.

How individuals untrained in logic are able to draw valid conclusions or determine for given conclusion if it is valid is a matter of controversy. (Johnson-Laird, 2008).

According to a very old idea, which origin is probably in the work of Aristotle, logic is concerned with discovering or illuminating the laws of thought. Its psychological corollary is that a system of logic (but maybe not the same as the first order logic) in the mind underlines our thinking processes. It is called The Mental Logic Theory (ML) and it holds that deduction rules are the exclusive tools of thought and abstract rules are applied to verbal/propositional representations. Evidence for this theory appeared mostly in the last few decades (see Rips, 1983).

In the same time a new theory has been formulated: The Mental Models Theory (MM), mostly due to the work of Johnson-Laird and his collaborators. MM also deals with the nature of the internal representations of deductive processes, but these theories differ in their supposed nature. The MM hypothesis posits that the engine of human reasoning relies on content, so valid inferences can be drawn without explicit representations of logical properties of relations. Instead, information is represented in the form of spatial arrays, akin to mental diagrams, from which further information can be inferred (see Johnson-Laird & Byrne, 1991). To infer that the inference is valid, a reasoner should try to find a counterexample in which premises are true, but the conclusion is false. If there is no such counterexample, the inference is valid (Johnson-Laird, 2008).

ML and MM are commonly perceived as disjunctive theories. In this work we will try to examine possibilities of their coexistence with respect of individual differences between reasoners, incorporating simplified versions of existing theories as possible strategies of reasoning.

Recent researches have suggested individual differences in strategies that reasoners use in solving reasoning (syllogistic) tasks and this is connected with other cognitive processes. Bacon, Handley, and Newstead (2003) and Ford (1995) have suggested that while some people prefer to use spatial representation of information, others are more likely to use verbal (propositional) strategy.

Furthermore, Bacon et al (2008) connected strategy that people choose when reasoning with better performance of verbal of spatial working memory.

2. REASONING
Reasoning is a fundamental cognitive activity which is present in every situation in which one needs to reach some conclusion. It involves the manipulation and the transformation (i.e. coding) of information in order to make inferences. A lot of researches that examine the process of reasoning use tasks including syllogisms, logical arguments containing two premises and conclusion. Conclusion can logically follow or not follow from premises and one of the most frequent tasks given to participants in those

researches is to determine if the conclusion follows from premises. For example:

Premise 1 All musicians are teachers.

Premise 2 Some writers are musicians.

Conclusion Some writers are teachers.

Reasoning like syllogistic is very common in everyday life: people should often make conclusions about category membership or relations between terms (for example: 'X is taller than Y. Y is taller than Z. Is X taller than Z?").

Every theory which presupposes that it can describe the process of reasoning in whole, at the same time presupposes that every reasoner makes inferences in the same way and that there are no individual differences between reasoners and mechanisms of reasoning.

Polk & Newel (1995) offered an alternative hypothesis that allows the presence of representational processes (i.e. mental models) and rule-based processes in human reasoning (i.e. mental logic). Each of those theories have their own representational strategy: for MM it is spatial strategy according to which information are represented in spatial configuration that corresponds to the state of affairs in the world, while for MM it is verbal strategy that represents information as thematic or abstract propositions.

According to those authors, reasoners firstly code information from premises in some kind of inner representation that can be proposition (verbal) or model (spatial). Choosing the way of representation can be determined by a level of familiarity and successfulness in each process: for example, if one is better in verbal abilities, he/she will choose verbal representation strategy and vice versa.

Research on categorical syllogisms conducted by Ford (1995) had confirmed the existence of individual differences in reasoning. With respect of obtained results, she divided reasoners into two groups: spatial and verbal. In solving syllogistic problems, spatial reasoners use shapes like circles or squares placed in various spatial relations to represent relations between premises. Verbal reasoners apply different types of substitution, so they substitute middle term from one premise with the last term from the second premise to reach the conclusion. Although the substitution described in that way indicates that reasoners use some kind of heuristics, Ford (1995) noted that the majority of verbal reasoners is aware of logical rules they use, for example that *All A are B* is not equivalent to *All B are A*.

Bacon et al. (2003) repeated Ford's research, but with more participants and in most cases participants showed typical verbal or spatial patterns of solving syllogisms, no matter of the way of examination (verbal or written) .

3. WORKING MEMORY

Extensive research over the past three decades has established that working memory is not a single store, but a memory system comprised of separable interacting components (see Gathercole and Alloway, 2014). Some researches (e.g. Logie and Salway, 1990) suggest that separate working memory components are involved in the short-term storage of verbal and visual information. Bacon et al. (2004) present evidence that suggest differences between the two strategies of reasoning with respect of how they draw on working memory resources.

Verbal and spatial strategy users did not differ in working memory capacity, but while verbal reasoners draw primarily on verbal working memory, spatial reasoners use both this and spatial resources. The distinction is further supported by brain imaging studies which have indicated that reasoners instructed to use either a verbal or spatial strategy show differing patterns of activation when subjected to fMRI (Reichle, Carpenter, & Just, 2000). Overall, this evidence converges to suggest that the inter-strategic differences described by Bacon et al. (2003) and Ford (1995) represent a fundamental difference in the way these two groups of individuals use information during reasoning.

The differences mentioned above are present in other cognitive functions as well. Authors Macleod et al. (1978) investigated the ways of how people confirm sentences describing relations between simple pictures, for example, *The plus is under the asterisk.* After seeing the sentence, pictures were shown to the participants and their task was to determine, in a very short time period, whether this sentence was a true description of the presented picture or not. The obtained results have shown that 61,43% participants conclude about truthfulness with respect of the representation of proposition, 22,86% participants convert sentence into pictorial representation, while 15,71% participants use some mixed strategy or apply both strategies.

MacLeod et al. (1978) concluded that choosing of the reasoning strategy, although unconscious, is connected with highly developed abilities, therefore participants who showed better language abilities on previous tests mostly chose verbal strategy, while participants with better spatial abilities chose spatial strategy.

3.1 Verbal and Spatial working memory in children

In order to research where those differences come from and what is the reason why some reasoners prefer one strategy; we tried to find a difference of spatial and verbal working memory present in children.

According to Alloway et al. (2006), the strength of association between verbal and visuospatial short-term memory increases slightly between the ages 4 to 6 and the ages 7–11. This can suggest that younger children initially rely more on visual strategy, and as they get older, they use strategies such as rehearsal to recode visual material using verbal labels, but more research is needed (and planned) to verify this presupposition.

4. CONCLUSION

To sum up, according to the evidence mentioned above, it can be presupposed that MM theory describes the way of reasoning that is developed earlier in childhood and could be partly innate, while ML theory describes reasoning strategy that can be developed later in life. Although all reasoners have possibility of using both strategies, the choice of strategy may differ according to the type of the reasoning task and/or individual differences in a level of familiarity and successfulness in each process.

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Psychophysiological responses during reading texts of different levels of complexity

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ABSTRACT
We studied how cognitive load during reading different texts is reflected in psychophysiological responses. The study involved 31 volunteers, aged 22 years on average. Three texts of different complexity were chosen (children's story, the novel, and a philosophical text). While the participants read each of the three texts, we measured their blood pressure, heart rate and skin conductance. After reading, they estimated the level of difficulty of each text. For control purposes, participants also filled in the anxiety questionnaire STAI X-1. The results showed that subjective difficulty of the text and the estimated level of invested mental effort are good indicators of differences in text complexity, whereas physiological measures show a high degree of interpersonal variability and are therefore, with the exception of the number of peaks in the amplitude of skin conductance (SCR) and heart rate, less reliable in differentiating the texts.

Keywords
task difficulty, cognitive load, heart rate, skin conductance, subjective assessment

1. INTRODUCTION

1.1 Cognitive load
The Cognitive Load Theory is based on knowledge of the cognitive architecture, consisting of working memory with a limited capacity and processing time of new information and long-term memory with unlimited capacity [1]. Number of items that can be kept in working memory decreases when items need to be comprehended and not just remembered. As the number of elements in the interaction increases, the difficulty of the task increases as well and so does the intrinsic cognitive load which a person experiences.
Knowledge about the structure and function of human cognition should be used to generate new and diverse learning/educational approaches. These should be based on the assumption that it is necessary to reduce the load on working memory and encourage the construction of mental schemes, with particular reference to interpersonal differences in cognitive abilities or working memory capacity [2]. This is why we need to study cognitive load that people experience in different educational tasks, e.g. in reading, and search for the indicators that would describe cognitive load with the highest possible validity.

1.2 Subjective assessment of cognitive load
The method of subjective assessment is based on the assumption that individuals are able to observe their own cognitive processes and report on the perceived level of difficulty and also invested mental effort [3]. Researchers report that the perceived difficulty and level of effort are useful indicators of cognitive load [4]. Different scales and questionnaires for subjective evaluation are used to measure the perceived difficulty and mental effort. The most commonly used are 7-point Likert-type [5, 6] or 9-point Likert type scales [7], where the category 1 indicates very little mental effort and the categories 7 or 9 indicate a lot of mental effort. Participants need to report how much mental effort they invested in the execution of a certain tasks. Self-assessment of the invested mental effort is thought to be a good measure of cognitive load because of its high reliability, validity and sensitivity [4].

1.3 Measurement of physiological indicators of cognitive load
The method of measuring (psycho)physiological variables is based on the assumption that cognitive functions are reflected in changes in the physiological state of the individual [4]. There is a high correlation between different physiological parameters and the activity of the autonomic nervous system, which depends on the psychophysiological state of the observed person [8]. Among the most often used parameters are changes in the conductivity of the skin, changes in the size of pupils, brain signals, or changes in heart rate and blood pressure. The variability of these parameters is high within the same person at different times and different psychological states. This is why studies often report about the change in psychophysiological parameters relative to the stable initial state (baseline phase). Such a change is expressed either as a relative change from the initial state (as a ratio of the treatment and the baseline phase) or as an absolute change from the initial state [8].
Galvanic skin response (or electrodermal activity) is a useful indicator in measuring mental activity and emotions. Based on skin conductance, researchers were able to successfully distinguish between the state of stress and the state of cognitive load [9] and found a (weak) effect of cognitive load on physiological signals, including skin conductance [10]. Researchers [11] were able to differentiate two levels of cognitive load based on the level of skin conductivity, more specifically, they found that skin conductivity decreases when the level of task difficulty increases, and explained the higher skin conductance level at the easier task with the nature of this task: it was monotonous and too easy. A different study [12] found with pilots that electrodermal activity of the skin increases during takeoff and landing, which are expectedly the phases of increased cognitive demands. Some other studies did not find significant differences in skin conductance in relation to two levels of cognitive load, which they explained as a consequence of a specific type of task that they used and insufficient accuracy of sensors for measuring electrodermal activity [13].
Use of changes in heart rate and blood pressure as indicators of cognitive load is based on the assumption that the controlled cognitive processing is associated with specific

cardiovascular conditions and is manifested through specific patterns of cardiac function [4]. Arterial blood pressure is one of the basic physiological parameters. It varies due to changes in the psychological state of the observed person [14, 15]. Blood pressure increases with the mental, emotional and physical exertion and slowly returns to the basic level [16]. Similarly, heart rate increases with increase in cognitive load. As a major cardiovascular parameter, heart rate represents a sensitive cognitive load indicator with fast adaptation to different stimuli [15]. Cognitive effort is thought to be directly related to the controlled processing, which in turn causes changes in the power spectrum of heart action. Heart rate variability is often used as an indicator of psychophysiological state of a person, but it poorly differentiates between different levels of cognitive load. It does, however, distinguish between mental inactivity phase and the stage of mental effort [3].
An important problem of using physiological measures in studying cognitive load is in large interpersonal variability of autonomous responses, which hampers direct comparisons between individuals [17]. Also, test anxiety causes cognitive and physiological changes before, during and/or after the measurement phase [18].

1.4 Research problem

The main purpose of the present study was to determine comparatively how cognitive load during reading texts of different complexity is reflected in the subjective and the phychophysiological measures.

2.0 METHOD

2.1 Participants

The study involved 31 university students (22 female and 9 male, average age 22 years) who volunteered to participate. All participants were previously aware that the participation in the experiment does not entail any special risks and gave written informed consent to participate in the study.

2.2 Structure of the experiment

Following the procedure in a study by DeStefano and LeFevre [19] we designed an experiment in which we varied the complexity of the text, which is crucially related to the understanding of the text and to cognitive load. Three texts varying in syntactic structure were chosen. We used an excerpt from (i) a children's story, (ii) the novel, and (iii) a philosophical text. We assumed that the complexity of the texts will increase from (i) to (iii). Physiological measurements were carried out in two phases: (i) the relaxation phase in which we recorded the baseline level heartbeat, blood pressure and skin conductance, and (ii) the cognitive load phase where the participants read one of the texts.

2.3 Measurement of physiological variables

Signals of cardiac function (heart rate, continuous systolic and diastolic blood pressure) were recorded with CNAP Monitor (CNAP Monitor 500 HD) [20]. The signals of skin conductance between the distal phalange of the index and middle finger of the left hand were measured by means of a Biopack MP150 physiological acquisition system. The measured signals were recorded and processed using AcqKnowledge software package [21].

2.4 Measurement of psychological variables

To obtain subjective evaluations of cognitive load, we used a self-developed questionnaire. Participants had to summarize the text read and had to assess the complexity of reading each text and the degree of their invested mental effort. They assessed the texts in the same order in which they were read. They used a 5-point rating scale, where 1 represented the lowest level and 5 represented the highest level of the assessed text property or subjective experience. We also wanted to control for the effect of state anxiety on these assessments and on physiological variables. To measure anxiety, a short version of STAI X-1 [22] was used.

2.5 Procedure

Upon arrival to the laboratory, participants sat on a chair at the table. They were introduced to the sequence of phases in the experimental procedure and signed an informed consent. The sensors for measuring heart rate and blood pressure (CNAP), and skin conductivity (Biopack) were placed, and the measurements started immediately. Then the exact instructions about the measurement process and participants' tasks followed. Participants filled in the anxiety questionnaire, and then the experiment started. After 180 s of the beginning relaxation phase, three texts were presented in succession. Each text was presented for 60 s, and there was a 2-minute break between them, during which the participants were instructed to relax. The texts were presented in random order for different participants. After the end of the experiment, participants filled in the anxiety questionnaire again and they had to provide subjective assessments of the texts.

2.6 Derivation of psychophysiological parameters

For each text separately, data about different physiological parameters – systolic, mean and diastolic blood pressure, heart rate and skin conductance level – were calculated. We calculated the ratio of the parameter value in the experimental condition (during reading the text) and its baseline level. With this ratio we are describing the relative change in the psychophysiological parameter. Use of such ratios enables us to compare data of different participants.
For the baseline level, the average value of a certain physiological parameter was calculated from the signals recorded in the last 15 seconds before the text appeared on the screen. The level of the parameters in experimental conditions was determined as the average value of the parameter in a 45-second interval during the reading of texts (excluding the first 15 seconds of text presentation due to the instability of values that most probably were related to the novelty of the stimulus, not to text difficulty). The logarithmic transforms of the parameters (relative changes) in different participants were then analysed with ANOVA.
As a measure of average changes in the measured skin conductance response SCR we used the number of events, i.e. the number of peaks in a given interval. We compared the absolute value obtained during the interval ranging from 15 seconds to 60 seconds of text reading.

2.7 Data analysis

We expected that texts will differ in the change of blood pressure amplitude, heart rate and skin conductance, depending on the difference in text complexity.
A mixed-design analysis of variance was used to study the effect of text complexity on physiological measures during reading. When the assumption of sphericity was violated, Greenhouse-Geisser correction of the degrees of freedom was used. In case of non-normally distributed pairwise differences between experimental conditions, we used Friedman non-parametric test instead of ANOVA. All hypotheses were tested at the 5% alpha error rate.

3. RESULTS

3.1 Subjective assessments of the complexity of the texts

We expected that texts of different complexity will be

assessed differently according to difficulty of reading, writing a summary, and the invested mental effort. Table 1 shows average assessments of different texts. Results of Friedman ANOVA showed that the texts differed according to all three dimensions.

Table 1. *Subjective difficulty of texts for reading, summarizing, and the assessed level of mental effort.*

	Text 1		Text 2		Text 3		
	M	*SD*	*M*	*SD*	*M*	*SD*	χ^2
Difficulty of summa-rising	1,6	0,6	2,8	1,0	3,5	0,9	34,3**
Mental effort	2,2	1,0	3,6	1,1	4,3	0,8	38,2**
Difficulty of reading	1,6	0,6	2,8	1,0	3,8	0,9	43,1**

**$p < .001$.

3.2 The impact of text complexity on physiological measures

The results of ANOVA showed statistically significant differences between texts in skin conductance SCR, $F(2, 60) = 3.76$, $p = .029$. The largest number of peaks in skin conductance were present during reading text 1 ($M = 5.97$, $SD = 3.18$), followed by text 2 ($M = 5.45$, $SD = 3.35$), and finally text 3 ($M = 4\ 77$, $SD = 2.47$). Sidak *post hoc* test showed the only statistically significant pairwise difference was the difference between texts 1 and 3 (mean difference = 1.19, $p = .038$).

Changes in heart rate between different texts correlated with state anxiety as measured with STAI X-1; changes between text 1 and 3 correlated with STAI X-1 (second measurement; $r = ,457$, $p = ,010$) and changes in heart rate between text 1 and 2 correlated with STAI X-1 (first measurement; $\rho = ,571$, $p = ,001$). Therefore, anxiety was also entered in the model for explaining the effects on the studied parameter. We performed analysis of covariance and used anxiety as a covariate. A statistically significant difference was found between the three texts, $F(1.62, 46.99) = 6.70$, $p = .005$). The largest changes in heart rate were observed in text 1 ($M = 0.0391$; $SD = 0.0367$), followed by text 3 ($M = 0.0335$; $SD = 0.0309$), and finally text 2 ($M = 0.0224$; $SD = 0.0466$).

No statistically significant differences between the three texts were spotted in other physiological parameters.

3.3 Relation between psychological and physiological responses

We expected that differences in subjective complexity of texts will correspond to changes in physiological measures. We compared the order of average subjective assessments and the order of average values of physiological parameters for the three texts. Aligning the two different types of averages, we found no systematic correspondence. For peaks in skin conductance (SCR), the highest number was found for text 1 and the lowest number was found for text 3. However, changes in heart rate did not follow the same pattern. Highest changes were found for text 1 and smallest were found for text 2. Furthermore, where there have been significant differences in the subjective estimates of the three texts, there has been no similar difference found in other physiological measures. Therefore, there was no consistency in the relation between subjective ratings and physiological measures.

4. DISCUSSION

The results showed important differences between subjective assessments of individual texts; consistent with our assumptions, text 1 was perceived as the easiest to read and text 3 as the most difficult. Perceived difficulty and level of mental effort while reading texts seem to be good indicators of cognitive load.

With regard to physiological responses, only skin conductance SCR and heart rate seem to reflect different cognitive load posed by different texts. In both parameters, the biggest changes were observed in text 1. It is difficult to compare our results to other studies, because the results of other studies are not consistent. For example, in some studies skin conductance fell when the level of difficulty of the task increased [11], and in some other studies skin conductance increased [9, 10, 12]. The results of our research showed that during reading a very difficult text, text 3, a smaller number of peaks in skin conductance was present compared to reading the least difficult text, text 1, whereas there was no difference between texts 1 and 2. This may show that text 1 and 2 were similar with regard to the cognitive load the reader experienced or that the measuring device was not sufficiently sensitive to detect physiological differences between the two texts. Text 1, a children's story, was easier to read and included familiar words only, whereas text 2 contained some less frequent, expert words and the content was less coherent. Text 3 was, according to participants' reports, difficult for understanding. They reported that they had invested a lot of mental effort in reading this text. However, it might be that, because it was most difficult to understand, their memory span which is necessary for synthesizing the contents was reduced, resulting in less vigorous processing. Perhaps participants were more emotionally aroused when reading text 1 and 2 or tried harder to understand and remember general idea, whereas text 3 was just too difficult to comprehend and synthesize. If this elaboration was correct, SCR rate might represent a measure of extracting a general message and remembering the text and not a measure of cognitive load related to the effort in attempting to understand smaller units of the text. This might also be the reason why changes in heart rate were not largest for text 3 as we expected, and instead largest changes in heart rate were obtained in text 1 which might have elicited the highest emotional arousal.

Conclusions drawn from this study must be taken with some caution. It is not yet clear which psychophysiological features are the most relevant indicators of cognitive load, which time interval would be best incorporated into the analysis of physiological signals, etc. Furthermore, our sample was not large enough to make firm conclusions. Due to large individual differences in psychophysiological responses that are related to stress reactivity and genetic predispositions of the individual, more data should be gathered for more reliable conclusions. Interpersonal variability in autonomous responses represents a major challenge for the development of universal psychophysiological methods for non-invasive determination of the level of cognitive load. In addition, the texts we selected may not be good representatives of different levels of text complexity, even though subjective assessments of text difficulty were in line with our expectations. Also, participants assessed the difficulty of all texts at the end of the session. It is possible that their assessments would be different had they assessed each text separately, immediately after they had read it. In future, texts should be chosen more systematically. Analysis of their structure should be done and based on this, more thematically similar texts should be chosen (e.g. texts of the same genre, from the same historic period) to reduce the effect of possible confounding variables, such as readers' experiences and prior knowledge.

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Learning From Material Conditionals

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ABSTRACT
In this paper, I describe the problem of learning from conditionals. I then propose a model based on material conditionals, which fits psychological data and the intuitively expected results surprisingly well. This may also provide a vindication of material conditionals in probabilistic reasoning.

Keywords
conditionals, formal modeling, learning, probability

1. INTRODUCTION
Some of the information that I learn comes to me in form of conditionals. Although conditionals do not seem to be much different from other compound sentences, it turns out their nature is so unusual that they might even constitute a special class of sentences. The problem is even harder in probabilistic scenarios where a related concept, conditional probability, plays an important role. It seems intuitively that probabilities of conditionals could, or even should, be interpreted as conditional probabilities, although as [12] and others (e.g. [9]) have shown, such claims lead to trivial results.

Psychologists of reasoning have, on the other hand, found a lot of evidence confirming the fact that people often understand probabilities of (simple) conditionals as conditional probabilities (e.g. [8], [7], [4]).[1] Although conditional probability seems to be the leading interpretation of probabilistic conditionals in human reasoning, participants in psychological experiments sometimes interpret conditionals in other ways, for example as (logical) conjunctions, biconditionals and so on. There are some explanations, which attribute this phenomenon to differences in cognitive development or other aspects [13]. It is important to note that the material interpretation of conditionals, i.e. the conditional is true, unless the antecedent is true and the consequent false, seems to be fairly untypical (see, for example, [18]).

A special problem that has only gained little research attention is how learning from conditionals proceeds. An agent learns something when she is told: "If it rains tomorrow, the picnic will be cancelled." It is intuitively clear that her belief in tomorrow's rain (the antecedent) should not change in light of the newly learned conditional, while her belief in tomorrow's picnic (the consequent) needs to adjust to her belief in rain.

It does not take much more than a few simple scenarios[2] to see that the belief in the antecedent may in other cases increase or decrease while the belief in the consequent remains unchanged or, vice-versa, the belief in the consequent changes while the belief in the antecedent remains the same.

Further, as experiments in psychology of reasoning show, the perceived causal structure of conditionals influences how participants interpret them. As I will show, perceived causal structure of conditionals also influences how learning from them proceeds.

Although everyday reasoners have no problems learning from conditionals, it is very hard to formally model learning from conditionals. I propose a method based on materially interpreted conditionals (or, simply material conditionals) and Bayesian nets, which turns out to be simpler than presently available methods and gives us a hope that it may also be extendable to nested conditionals, which are out of the range for current methods.

2. BELIEF UPDATING
Two cornerstones on developing such a method are dynamics of beliefs updating and an analysis of indicative conditionals[3]. Let me first examine the former. A lot of research has been made on the issue of belief updating and it seems the formalities of belief dynamics are well understood by now. The dynamics of partial beliefs play a central role in Bayesian epistemology where they are modeled with various updating mechanisms. I consider three, listed according to their generality, from the most particular to the most gen-

[1] Interestingly, recent studies show that this may also hold for counterfactual conditionals, e.g. [15].

[2] For an overview of such scenarios refer to [4].

[3] When I refer to indicative conditionals, the connective is denoted by a single arrow ($\rightarrow$) as in $p \rightarrow q$. Material conditionals are denoted by a horse-shoe connective ($\supset$), e.g. $p \supset q$.

eral: (1) Standard Bayesian updating (SBU), (2) Jeffrey-style updating (JSU), and (3) Minimizing Kullback-Leibler divergence (MKL).

The main idea behind (1) is very straight-forward. An epistemic agent starts with a prior conditional belief measured by conditional probability $Pr(A|B)$. After learning B, i.e. $Pr'(B) = 1$, her posterior belief changes to

$$Pr'(A) = Pr(A|B) \tag{1}$$

This idea is widely accepted. It comes with a price, though. Updating only proceeds if the condition is learned with full certainty. In the above case, if $Pr'(B) = 1$.

It is, however, often the case that a new piece of evidence is not learned with full certainty. Jeffrey-style updating (also known as probability kinematics) provides a generalization of (1) for exactly these cases. Formally:

$$Pr'(A) = Pr(A|B)Pr'(B) + Pr(A|\neg B)Pr'(\neg B) \tag{2}$$

It is obvious from the equations that (1) is just a special case of (2) when $Pr'(B) = 1$.

Minimizing Kullback-Leibler divergence is an even more general approach to updating, where Kullback-Leibler divergence between the posterior and prior probability distributions is first calculated. Formally:

$$D_{KL}(Pr'||Pr) = \sum_i Pr'(i) \cdot log\frac{Pr'(i)}{Pr(i)} \tag{3}$$

When the above divergence is minimized,[4] the probability distribution is properly updated.

Standard assumption in analyzes of learning from conditionals is that learning a conditional means that one learns a new conditional probability, although such an approach is problematic. As already mentioned, if the conditional is interpreted as conditional probabilitiy, i.e. $Pr(P \rightarrow Q) = Pr(Q|P)$, this formally leads to triviality results.

Conditional probability also only takes propositional variables for its arguments as non-propositional variables cannot take part in Boolean compounds. While there is no unanimous view on the (non)-propositional nature of indicative conditionals, many philosophers claim that indicative conditionals are non-propositional and non-truth-functional (or, in the best case, partially truth-functional), as put forward by e.g. [1] and [2].

On the other hand, if the conditionals are interpreted as material conditionals, all of these problems are overcome.

3. THE TROUBLES WITH MATERIAL CONDITIONALS

Indicative conditionals in natural language at first sight appear to actually be material conditionals (MA), or at least very closely related to them. (MA) also has many advantages over other accounts of indicative conditionals: it is semantically simple, truth functional, allows nesting and has been been proven as useful throughout the history of logic.

Why does the majority of researchers of conditionals both in philosophy and psychology then reject (MA) as an analysis of indicative conditionals in natural language? The biggest problem lies in seemingly too simple semantics (a conditional is true if either the antecedent is false or the consequent is true), which enables a number of paradoxes. Let me point out a few of them, which are all based on the following equivalence: $p \supset q \Leftrightarrow \neg p \vee q$.

The paradoxic nature of material conditionals becomes clearer when their truth is based on a single clause, either the false antecedent or the true consequent. The following conditional is thus true according to (MA) because the antecedent is false: "If Europe is not a continent, then Europe is a continent." ($\neg E \supset E$)

Further problems are with contraposition, transitivity and strengthening of the antecedent, which are all valid inferential schemes for (MA), but not always acceptable in natural language indicative conditionals. For example (transitivity, from [11]) "If there is an avalanche, there is snow on the ground ($a \rightarrow b$). If there is snow on the ground, I will go skiing ($b \rightarrow c$). Therefore, if there is an avalanche, I will go skiing ($a \rightarrow c$)." The conclusion is obviously absurd.

Although not in majority, a number of influential philosophers (e.g. P. Grice, D. Lewis, F. Jackson) have argued in favor of (MA) in analyses of indicative conditionals despite these problems. As will be demonstrated, (MA), perhaps unexpectedly, also enables a very efficient modeling of learning from conditionals.

4. LEARNING FROM CONDITIONALS

Not many promising models of learning from conditionals have been developed so far. Let me briefly introduce two of them.

Douven and colleagues ([5], [6], [4]) provided a few different scenarios of updating on indicative conditionals to demonstrate different ways in which beliefs in the constituents of the conditional, i.e. the antecedent or the consequent, may change after learning the conditional. They consider different approaches (e.g. epistemic entrenchment in [5]), and most recently focus on the explanatory status of the antecedent, which may or may not change after learning an indicative conditional ([4]). If the explanatory status of the antecedent does not change after learning the conditional, updating proceeds as a special case of Jeffrey-style updating (called Adams' conditioning) and the degree of belief in the antecedent remains the same. Otherwise the belief in the antecedent increases or decreases accordingly to the change in its explanatory status.

This approach has a few problems. As [14] noted, the exact role of explanatory considerations in probabilistic reasoning still has to be clarified. Further, what is the difference between the explanatory status (ES) of the antecedent and its probability which seemingly go hand in hand?

[4]To find minimums, the divergence needs to first be differentiated with respect to posterior variables, and then set to zero to find the extremes. Second-order derivation may further be applied to check if the extremes are indeed minimums.

Another model was provided in [10]. The authors try to account for the examples Douven et al. and Van Fraassen ([17]) provided. Their chosen updating mechanism is minimizing Kullback-Leibler divergence in combination with properly represented causal structures of scenarios (in causal Bayes nets).

They first translate the problem on hand into a proper representation of its causal structure. They then minimize the KL divergence between the prior and posterior probability distribution over the structural representation, with the newly learned conditional as a constraint on the new distribution. They follow [4] (although without the approximization) in this regard as they model learning a conditional $P \rightarrow Q$ as setting $Pr(Q|P) = 1$[5]

Their model is successful as its results are close to intuitively expected results, but it is also formally quite complicated and only takes simple non-nested conditionals into consideration.

As the authors noted in one of the footnotes, it turns out that in some cases the standard Bayesian updating provides correct results if the proper causal representation of the scenario is taken into account and the learned conditional is interpreted as a material conditional. This is also the basis of my proposed method.

5. CONTENT-EFFECT IN CONDITIONALS

Another important aspect in psychological research of conditionals is content-dependance. When people are reasoning with conditionals, they often follow these two schemes: denying the antecedent ($p \supset q, \neg p, \therefore \neg q$; DA) and affirming the consequent ($p \supset q, q, \therefore p$; AC).

Both DA and AC are invalid according to (MA). A negated consequent ($\neg q$) does not logically follow from a denied antecedent. Similarly, in a true conditional the antecedent may be false although the consequent is true.

But why are then such inferences so frequent? One of the reasons is that people do not consider conditionals in a logical vacuum. Exactly the opposite, the background and context beliefs play an important role in reasoning as psychological experiments show, e.g. [16].

Consider the following conditional: "If the TV is plugged in, then it works." As it is already know that the antecedent in this example is a necessary (although not sufficient) cause for its consequent, i.e. the consequent cannot be true if the antecedent is not true, (DA) and (AC) come naturally to our reasoning. Even more, as the antecedent is not sufficient for the consequent, i.e. if the antecedent is true, the consequent may still be false, two of the most basic logical operations, modus ponens (MP) and modus tollens (MT), strike us as strange.[6]

[5]This is at least how they model learning in most cases. There are some examples where their approach is more general. For example, in the Judy Benjamin problem where Judy learns that the conditional is only probable to the degree of 3/4, they simply say that the newly learned conditional is learned with probability k, i.e. $Pr(Q|P) = k$, with $k = 3/4$.

6. STRUCTURAL REPRESENTATIONS

It turns out that sufficiency and necessity relations are also deeply related to modeling learning from (uncertain) conditionals.

[4] and [10], for example, claim that when agents learn a conditional $p \rightarrow q$, they interpret it as a conditional probability $Pr(q|p) = 1$, or, as the conditionals are usually learned from testimony, at least close to 1, i.e. $Pr(q|p) \approx 1$ ([4]). This implies that after learning the conditional, what the agent actually learns is that the antecedent is sufficient, or almost sufficient for the consequent to follow. Let me demonstrate this on an example from [4].

> Sarah and Marian have arranged to go for sundowners at the Westcliff hotel tomorrow. Sarah feels it might rain, but thinks they can always enjoy the view from inside. To make sure, Marian consults the staff at the hotel and finds out that in the event of rain, the inside area will be occupied by a wedding party. So she tells Sarah: **If it rains tomorrow, we cannot have sundowners at the Westcliff.** Upon learning this conditional, Sarah sets her probability for sundowners and rain to 0, but she does not adapt her probability for rain.

It is clear from the story that Sarah does not think rain is sufficient to prevent them from having the sundowners at the hotel. But when she learns the conditional, she realizes that it would only make sense for her sister to assert it if she thought that the antecedent of "If it rains tomorrow, we can't have sundowners" suffices, i.e. she implicitly learns that they cannot have the sundowners inside.

More insight into the whole situation may be obtained if the scenario is translated to a causal network, as in [10]. It is clear from Figure 1 that when Sarah learns that rain is sufficient to prevent their sundowners, she also learns that the other cause(s), in this case the wedding inside the hotel, is fulfilled.

7. LEARNING MATERIAL CONDITIONALS

To demonstrate my proposed method, consider that Sarah learns the material conditional ($r \supset \neg s$) and, implicitly that there is something going on at the hotel the next day (w). Further, she already knows that they cannot have sundowners if it both rains and inside area is occupied ($Pr(s|r \wedge w) = 0$). It turns out that the following equation holds (details omitted):

$$Pr^*(r) = Pr(r|(r \supset \neg s) \wedge w) = Pr(r|(\neg r \vee \neg s) \wedge w) = \frac{Pr(r \wedge \neg s \wedge w)}{Pr((\neg r \wedge w) \vee (\neg s \wedge w))} = Pr(r) \quad (4)$$

[6]Modus ponens is the name for the following scheme: 1. $p \supset q$, 2. p. 3. $\therefore q$. Modus tollens describes the reverse: 1.$p \supset q$, 2.$\neg q$. 3. $\therefore \neg p$.

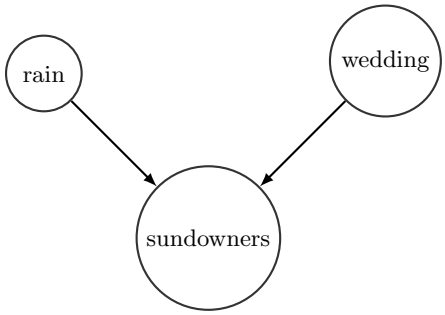

Figure 1: The Sundowners scenario represented in a collider causal network

After learning the (material) conditional, Sarah's belief in the antecedent (it will rain tomorrow) remains unchanged.

Similarly, learning material conditionals in other types of representations (chains and common causes) leads to intuitively expected, and formally exactly the same results as minimizing KL divergence and learning conditional probabilities.

As Popper (cited in [3]) proved back in the 1930's, the probability of material conditionals ($Pr(A \supset B)$) is greater or equal than the adequate conditional probability ($Pr(B|A)$). The two are equal if and only if the antecedent's probability is one, $Pr(A) = 1$ or the corresponding conditional probability $Pr(B|A) = 1$.

This suggests that material conditionals, although generally unpopular, may be especially fit for models of learning from conditionals as both known models are based on the assumption that learning a conditional is best represented by setting the corresponding conditional probability to, or close to, 1. In this case the probability of (MA) is the same as cond. probability.

8. CONCLUSION

I have demonstrated that learning from conditionals leads to expected results if the conditional is interpreted materially and the correct structural representation is taken into account. This approach has a few advantages over other models. In comparison to [4], it avoids the unclear notion of explanatory statuses.

In comparison to minimizing of Kullback-Leibler's divergence, it provides a much simpler formal apparatus, especially if more complex cases are considered.

One promising feature of the described approach, which needs to be addressed in the future, are nested conditionals. If the conditionals are interpreted materially, nesting provides no real issues. Neither of the other two approaches is able to do this as both interpret probabilities of conditionals as conditional probabilities.

It is not surprising that analyzing learning from conditionals with Bayes networks is so efficient and in line with experiments on the influence of the conditional content and the perceived sufficiency/necessity. Further psychological research could, however, provide more insight in the proposed models and confirm or falsify intuitions, which are often unreliable. It remains to be answered if material conditionals can be fully resurrected, but although old-fashioned they still prove as promising and should not be explained away too quickly.

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