The 15th International Conference
on Brain Informatics
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Abstract Note

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B265  Influences of Social Learning in Individual Perception and Decision Making in People with Autism: A Computational Approach
Estimating the Temporal Evolution of Synaptic Weights from Dynamic Functional Connectivity

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Abstract:

How to capture the temporal evolution of synaptic weights from measures of dynamic functional connectivity (DFC) between the activity of different simultaneously recorded neurons is an important and open problem in systems neuroscience. To address this issue, we first simulated models of recurrent neural networks of spiking neurons that had a spike-timing-dependent plasticity mechanism generating time-varying synaptic and functional coupling. We then used these simulations to test analytical approaches that relate dynamic functional connectivity to time-varying synaptic connectivity. We investigated how to use different measures of directed DFC, such as cross-covariance and transfer entropy, to build algorithms that infer how synaptic weights evolve over time. We found that, while both cross-covariance and transfer entropy provide robust estimates of structural connectivity and communication delays, cross-covariance better captures the evolution of synaptic weights over time. We also established how leveraging estimates of connectivity derived from entire simulated recordings could further boost the estimation of time-varying synaptic weights from the DFC. These results provide useful information to estimate accurately time variations of synaptic strength from spiking activity measures.

Keywords:

Dynamic Functional Connectivity, Spiking Neural Network, Communication Delay, Transfer Entropy, Cross-Covariance
Prediction of Neuropsychological Scores from Functional Connectivity Matrices Using Deep Autoencoders

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Abstract:

Deep learning models are being increasingly used in precision medicine thanks to their ability to provide accurate predictions of clinical outcome from large-scale datasets of patient’s records. However, in many cases data scarcity has forced the adoption of simpler (linear) feature extraction methods, which are less prone to overfitting. In this work, we exploit data augmentation and transfer learning techniques to show that deep, non-linear autoencoders can in fact extract relevant features from resting state functional connectivity matrices of stroke patients, even when the available data is modest. The latent representations extracted by the autoencoders can then be given as input to regularized regression methods to predict neuropsychological scores, significantly outperforming recently proposed methods based on linear feature extraction.

Keywords:

Resting State Networks, Functional Connectivity, Deep Learning, Feature Extraction, Predictive Modeling
A Machine Learning Approach for Early Detection of Postpartum Depression in Bangladesh

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Abstract:

Postpartum depression is a severe mental health issue exhibited among perinatal women after the childbirth process. While the negative impact of postpartum depression is extensive in developing countries, there is a significant lack of proper tools and techniques to predict the disorder due to negligence. This work proposes a machine learning-based system for finding the risk factors and prevalence of postpartum depression in Bangladesh. We developed a survey of different socio-demographic questions and modified questions from two standard postpartum depression screening scales (EPDS, PHQ-2). Data from 150 omen have been collected, processed, and implemented in different machine learning models to find—the best performing models. Based on the collected data of the perinatal women in Bangladesh, the best performing machine learning model was Random Forest. The performance metrics or the best model were AUC: 98%, Accuracy: 89%, and Sensitivity: 9%. The performance of the models varies from 88%-98% (AUC), 82%-89% (Accuracy), and 81%-89% (Sensitivity). We have also found the top risk factors for causing PPD. According to this work, the prevalence of PPD in Bangladesh is 66.7% (Considering the medium and high chance of PPD). This proposed work is the first to detect the risk factors and prevalence of PPD in Bangladesh using a machine learning approach.

Keywords:

Depression, Postpartum Depression, Machine Learning, Detection Model, Mental Health.
From Concrete to Abstract Rules: A Computational Sketch

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Abstract:
A multi-dimensional stimulus can elicit a range of responses depending on which dimension or combination of dimensions is considered. Such selection can be implicit, providing a fast and automatic selection, or explicit, providing a slower but contextualized selection. Both forms are important but do not derive from the same processes. Implicit selection results generally from a slow and progressive learning that leads to a simple response (concrete / first-order) while explicit selection derives from a deliberative process that allows to have more complex and structured response (abstract / second-order). The prefrontal cortex (PFC) is believed to provide the ability to contextualize concrete rules that leads to the acquisition of abstract rules even though the exact mechanisms are still largely unknown. The question we address in this paper is precisely about the acquisition, the representation and the selection of such abstract rules. Using two models from the literature (PBWM and HER), we explain that they both provide a partial but differentiated answer such that their unification offers a complete picture.

Keywords:
Cognitive Control, Prefrontal Cortex, Computational Model, Abstract Rules
Influences of Social Learning in Individual Perception and Decision Making in People with Autism: A Computational Approach

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Abstract:

The present paper proposes a computational approach to explore the influences of social learning on social cognition among individuals with Autism Spectrum Disorder (ASD) compared to the Typically Developing (TD) group. An experimental paradigm is designed to perceive and differentiate social cues related to real-time road and traffic light situations. The computational metrics such as sensitivity index (d’), response bias (c) and detection accuracy (DA) are recorded and analysed using machine learning classifiers. The results revealed that cognitive level is attenuated in ASD (d’= 0.427, c = −0.0076 and DA = 51.67%) compared to TD (d’= 1.42, c = −0.0027 and DA = 80.33%) with an improvement considering social influence as key factor (Sf) with best fit quantitative value for ASD (Sf = 0.3197) when compared to TD (Sf = 0.3937). The automated classification with an accuracy of 96.2% supported the significance of the metrics in distinguishing ASD from TDs. The present findings revealed that social conformity and social influence imparted growth in ASD cognition.

Keywords:
Support Vector Machine (SVM), Machine Learning, Correlation Coefficient, Social Learning
Investigations of Human Information Processing Systems

B203 Optimizing Measures of Information Encoding in Astrocytic Calcium Signals

B204 Analysis of Alpha Band Decomposition in Different Level-k Scenarios with Semantic Processing

B208 Toward the Study of the Neural-Underpinnings of Dyslexia During Final-Phoneme Elision: A Machine Learning Approach

B227 Root-Cause Analysis of Activation Cascade Differences in Brain Networks

B231 Unstructured Categorization with Probabilistic Feedback: Learning Accuracy versus Response Time

B233 Brain Source Reconstruction Solution Quality Assessment with Spatial Graph Frequency Features
Optimizing measures of information encoding in astrocytic calcium signals

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Abstract:

While most models of brain information encoding focus on neurons, recent studies have shown that calcium dynamics of astrocytes, the major class of non-neural cells in the brain, can add information about key cognitive variables that is not found in the activity of nearby neurons. This raises the question of what could be the contribution of astrocytes in information processing, and calls for analysis tools to characterize this contribution. Here we construct simulations with realistic dependencies of astrocytic activity on external variables and we use these simulations to understand how to optimally set parameters of information theoretic analysis of astrocytic activities. Applications of our techniques to simulated and real astrocytic data show how to set parameters of information analyses that provide conservative, yet reliable, estimates of astrocytic calcium dynamics contribution to circuit-level brain information processing.

Keywords:

Mutual Information, Astrocytes, Significance Testing, Information Estimation
Analysis of Alpha Band Decomposition in Different Level-k Scenarios with Semantic Processing

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Abstract:

A coordination game is one in which two players are rewarded for making the same choice from the same set of alternatives. The ability of humans to tacitly coordinate effectively is based on the identification of pronounced solutions associated with salient features attracting the player's attention. These prominent solutions are referred to as focal points. Game theory fails to account for how people make decisions in tacit coordination games, and human behavior in these games cannot be explained by a single theory. One of the accepted theories for explaining human behavior is level-k theory. This theory assumes that each player has a different level of reasoning by which she assesses the behavior of other players in the game and makes strategic decisions based on that assessment. In Previous studies, we have found an association between the players' cognitive load as reflected by EEG power and the level-k during the coordination game. The goal of the current study was to examine the relationship between alpha frequency and its sub-bands and level-k during a tacit coordination game in the context of semantic processing.

Keywords:

EEG, Tacit Coordination Games, Focal Points, Alpha Band
Toward the Study of the Neural-Underpinnings of Dyslexia During Final-Phoneme Elision: A Machine Learning Approach

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Abstract:

Identifying the neural basis of dyslexia is a fundamental goal of developmental neuroscience. Final-phoneme elision (FPE) test is a paradigm used for assessing phonological deficit (PD), which is widely considered a causal risk factor for dyslexia. However, the causal relationship between PD to dyslexia has been examined primarily based on behavioral observations. Towards facilitating the exploration of the neurophysiological origins of the theorized link between PD and dyslexia, we set out to isolate differential neural activation patterns in children with dyslexia during FPE. Accordingly, we present a machine-learning-based approach to identifying differential brain activity in children with dyslexia and controls during the FPE. Our method formulates an optimization problem to extract informative EEG components based on the ‘Neural-congruency hypothesis’, termed Phoneme-related Neural-congruency components. It then uses a machine-learning algorithm to optimally combine the resulting components to differentiate between the neural activity of children with dyslexia and controls. We apply our approach to a real EEG dataset involving children with dyslexia and controls. Our findings demonstrate that our method generates novel insights into the neural underpinnings of dyslexia and the potential neural origins of phonological deficits as a causal factor of dyslexia. Notably, our approach overcomes several methodological challenges in conventional EEG analysis methods; therefore, it could be utilized in studying the neural origins of other behaviorally defined developmental disorders previously overlooked because of such methodological constraints.

Keywords:

Electroencephalography, EEG, Neural-Congruency, Dyslexia, Final-Phoneme Elision, Neural-Based Models
Root-Cause Analysis of Activation Cascade Differences in Brain Networks

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Abstract:
Diffusion MRI imaging and tractography algorithms have enabled the mapping of the macro-scale connectome of the entire brain. At the functional level, probably the simplest way to study the dynamics of macro-scale brain activity is to compute the “activation cascade” that follows the artificial stimulation of a source region. Such cascades can be computed using the Linear Threshold model on a weighted graph representation of the connectome. The question we focus on is: if we are given such activation cascades for two groups, say A and B (e.g., controls versus a mental disorder), what is the smallest set of brain connectivity (graph edge weight) changes that are sufficient to explain the observed differences in the activation cascades between the two groups? We have developed and computationally validated an efficient algorithm, TRACED, to solve the previous problem. We argue that this approach to compare the connectomes of two groups, based on activation cascades, is more insightful than simply identifying “static” network differences (such as edges with large weight or centrality differences). We have also applied the proposed method in the comparison between a Major Depressive Disorder (MDD) group versus healthy controls and briefly report the resulting set of connections that cause most of the observed cascade differences.

Keywords:
Connectome, Structural Brain Networks, Activation Cascade, Root-Cause Analysis
Unstructured Categorization with Probabilistic Feedback: Learning Accuracy versus Response Time

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Abstract:
Contradictory data exist whether the category number affects the learning performance in rule-based and integration-information classification tasks. When an effect is observed, the performance is better for a lower number of categories. We aimed to investigate the effect of the category number on the performance in the unstructured category learning tasks with probabilistic feedback. We conducted four experiments. The stimuli consisted of dot motion sequences. We presented eight motion directions (0°-315° through 45°) with motion direction coherence of 75% (Experiments 1, 3, and 4) and 20% (Experiment 2). We used the probabilistic rule of 79% (Experiments 1-3) or 75% (Experiment 4) correct answers. Eight observers classified the eight stimuli into 8 categories (Experiments 1-2); 2 categories (Experiment 3); 4 categories (Experiment 4). The results show: 1.) a wide variety of strategies adopted by the observers; 2.) Accuracy and response time changed at a different rate during learning; 3.) The rate of improvement differed between the experiments; 4.) The response time is a better characteristic of incremental category learning. The findings imply that the learning performance depends predominantly on the complexity of the rule of stimulus-response associations and to a lesser extent task's difficulty.

Keywords:
Accuracy, Learning, Probabilistic Feedback, Response Time, Unstructured Category Learning
Brain Source Reconstruction Solution Quality Assessment with Spatial Graph Frequency Features

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Abstract:

Different EEG/MEG source imaging (ESI) algorithms can render different reconstructions, so as to the same algorithm with different hyperparameters. Moreover, we found the locations of active sources also have an impact on the performance of ESI algorithms. For the real EEG/MEG source reconstruction, as the ground true activation is unknown, it is hard to validate which algorithm performs better. In this paper, we proposed to use statistical features from source space to predict whether the reconstruction is a satisfactory solution. The training data and testing data are from solutions from different algorithms based on synthetic EEG data where ground truth activations are available. The good and bad solutions are determined by Area Under Curve (AUC) and localization error (LE). We extract spatial and general statistical features from solutions, then we used machine learning models to classify good vs. bad solutions, and showed the feasibility of judging the quality of solution without knowing ground truth, which can serve as a feedback for further hyperparameter tuning.

Keywords:

Brain Source Imaging, Solution Quality, Graph Fourier Transform, EEG/MEG
### Brain Big Data Analytics, Curation and Management

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Introducing the Rank-Biased Overlap as Similarity Measure for Feature Importance in Explainable Machine Learning: A Case study on Parkinson’s Disease

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Abstract.

Feature importance is one of the most common explanations provided by Machine Learning (ML). However, different classification algorithms or different training sets could produce different rankings of predictive features. Thus, the quantification of differences between feature importance is crucial for assessing model trustworthiness. Rank-biased Overlap (RBO) is a similarity measure between incomplete, top-weighted and indefinite rankings, which are all characteristics of feature importance. In RBO, tuning persistence p allows to truncate rankings at any arbitrary depth, so to evaluate their overlapping size at increasing number of features. Classification of Parkinson’s disease (PD) with Explainable Boosting Machine (EBM) was chosen here as case study for introducing RBO in ML. An imbalanced dataset, 168 healthy controls (HC) and 396 PD patients, with 178 among clinical and imaging features was obtained from PPMI. Imbalanced, undersampled (K-Medoids) and oversampled (SMOTE) datasets were used for training EBMs, obtaining their respective feature importance. RBO score was calculated between ranking pairs incrementally increasing the depth by five features, from 1 to 178. All classifiers reached excellent AUC-ROC (~1) on test set, demonstrating the EBM prediction stability when trained on imbalanced datasets. RBO revealed that the maximum size of overlapping (80%) among rankings was obtained truncating at top 40 features, while their similarity decreased asymptotically to 50% when more than 45 features were considered. Thanks to RBO it was possible to demonstrate that, for the same accuracy, the more similar are the feature importance, the more stable is the model and the more reliable is the ML interpretability.

Keywords:

Explainable Machine Learning, Feature Importance, Parkinson’s Disease, Rank-Biased Overlap
Classifying EEG Signals of Mind-Wandering Across Different Styles of Meditation

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Abstract:

In the modern world, it is easy to get lost in thought, partly because of the vast knowledge available at our fingertips via smartphones that divide our cognitive resources and partly because of our intrinsic thoughts. In this work, we aim to find the differences in the neural signatures of mind-wandering and meditation that are common across different meditative styles. We use EEG recording done during meditation sessions by experts of different meditative styles, namely shamatha, zazen, dzogchen, and visualization. We evaluate the models using the leave-one-out validation technique to train on three meditative styles and test the fourth left-out style. With this method, we achieve an average classification accuracy of above 70%, suggesting that EEG signals of meditation techniques have a unique neural signature across meditative styles and can be differentiated from mind-wandering states. In addition, we generate lower-dimensional embeddings from higher-dimensional ones using t-SNE, PCA, and LLE algorithms and observe visual differences in embeddings between meditation and mind-wandering. We also discuss the general flow of the proposed design and contributions to the field of neuro-feedback-enabled mind-wandering detection and correction devices.

Keywords:

Meditation, Mind-Wandering, Classification, Machine Learning, Deep Learning, Cognition, Neuro-Feedback, EEG
Feature Fusion-Based Capsule Network for Cross Subject Mental Workload Classification

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Abstract:
In a complex human-computer interaction system, estimating mental workload based on electroencephalogram (EEG) plays a vital role in the system adaption in accordance with users’ mental state. Compared to within-subject classification, cross-subject classification is more challenging due to larger variation across subjects. In this paper, we targeted the cross-subject mental workload classification and attempted to improve the performance. A capsule network capturing structural relationships between features of power spectral density and brain connectivity was proposed. The comparison results showed that it achieved a cross-subject classification accuracy of 45.11%, which was superior to the compared methods (e.g., convolutional neural network and support vector machine). The results also demonstrated feature fusion positively contributed to the cross-subject workload classification. Our study could benefit the future development of a real-time workload detection system unspecific to subjects.

Keywords:
Mental Workload Classification, Capsule Network, Feature Fusion, Cross-Subject, EEG, Brain Connectivity, Power Spectral Density
Towards Machine Learning Driven Self-Guided Virtual Reality Exposure Therapy based on Arousal State Detection from Multimodal Data

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Abstract:

Virtual-reality exposure therapy (VRET) is a novel intervention technique that allows individuals to experience anxiety evoking stimuli in a safe environment, to recognise specific triggers and gradually increase their exposure to perceived threats. Public-speaking anxiety (PSA) is very common form of social anxiety, characterised by stressful arousal and anxiety generated when presenting to an audience. In self-guided VRET participants can gradually increase their tolerance to exposure and reduce anxiety induced arousal and PSA over time. However, creating such a VR environment and determining physiological indices of anxiety induced arousal or distress is an open challenge. Environment modelling, character creation and animation, psychological state determination and the use of machine learning models for anxiety or stress detection are equally important, and multi-disciplinary expertise is required. In this work, we have explored a series of machine learning models with publicly available data sets (using electroencephalogram and heart rate variability) to predict arousal states. If we can detect anxiety induced arousal, we can trigger calming activities to allow individuals to cope with and overcome the distress. Here, we discuss the means of effective selection of machine learning models and parameters in arousal detection. We propose a pipeline to overcome the model selection problem with different parameter settings in the context of Virtual Reality Exposure Therapy. This pipeline can be extended to many other domains of interest, where arousal detection is crucial.

Keywords:

Arousal, EEG, HRV, Random Forest, Glossophobia, Stress · VRET
Convex Hull in Brain Tumor Segmentation

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Abstract:

Tumors are the second leading cause of death. Among the tumors, brain tumors constitute one of the most complex tumor categories with a high mortality rate. Therefore, brain tumor detection and segmentation from non-invasive imaging like MRI is an important research area. Although most recent researches for brain tumor detection are focused on deep learning methods, machine learning, geometrical approaches, thresholding and hybrid models are also explored frequently. In this paper, a novel brain tumor segmentation method containing thresholding, computational geometry and heuristics is proposed. The proposed model is tested with two brain tumor datasets to show comparative results for brain tumor segmentation with thresholding, convex hull and an area heuristic. The application of different filtering on a direct convex hull model and a heuristic-based convex hull model shows that the convex area based heuristic with the convex hull approach is able to segment brain tumors more accurately than previous approaches.

Keywords:

Brain Tumor, Image Analysis, Convex Hull, Segmentation
COSLETS: Recognition of Emotions Based on EEG Signals

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Abstract:

In the recent years, one of the leading technology which is earning greater mode of interest in the growing various fields of artificial intelligence is Brain computer interfaces (BCI). Recognizing emotions based on physiological signals specifically, Electroencephalography (EEG) signals with advancement of BCI applications, has turn into a very popular research topic. In this paper for effective representation of features the proposed model adopts COSLETS transformation approach, a combination DCT (Discrete Cosine Transform) and wavelets Transform. The obtained set of features is mapped on to the low dimensional subspace to employ principal components using PCA and finally GRNN (General Regression Neural Network) is presented for effective classification of four different emotional states from publicly available EEG based GAMEEMO dataset. The experimental results are promising and performed well, compared to other state of methods.

Keywords:
BCI-Brain Computer Interfaces, EEG Signals, Emotion Recognition, COSLETS, GRNN
Informatics Paradigms for Brain and Mental Health Research

B228 Computer-Aided Diagnosis Framework for ADHD Detection using Quantitative EEG

B235 Epilepsy Detection from EEG Data using a Hybrid CNN-LSTM Model

B237 Classifying Brain Tumor from MRI Images Using Parallel CNN Model

B241 Triplet-loss based Siamese Convolutional Neural Network for 4-Way Classification of Alzheimer’s Disease

B246 Understanding Syntax Structure of Language after a Head Injury

B254 Feature-Selected Graph Spatial Attention Network for Addictive Brain-Networks Identification
Computer-Aided Diagnosis Framework for ADHD Detection using Quantitative EEG

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Abstract:

Attention Deficit Hyperactivity Disorder (ADHD) is a mental disorder that is marked by abnormally high levels of impulsivity, hyperactivity and inattention. One of the methods to detect and diagnose brain disorders is Electroencephalogram (EEG). This paper proposes a framework that uses Quantitative Electroencephalogram (QEEG) features to diagnose ADHD in children. A 19-channel EEG signal is used to extract the spectral, amplitude, functional connectivity and Range EEG (rEEG) features from five frequency bands to diagnose ADHD children. Four feature selection methods: ANOVA, Chi-square, Gini Index and Information Gain are used to rank the QEEG features based on their relative importance to the classification task. The feature ranks are then averaged and the top-600 most discriminative features are passed as the input to an array of classifiers. We carried out experiments on a benchmark ADHD dataset and proved that our proposed framework gives better accuracy as compared to the state of the art. The highest accuracy of 81.82% is obtained with the Random Forest classifier, while the KNN, SVM and ANN classifiers yield accuracies of 78.51%, 76.86% and 76.93%, respectively.

Keywords:
Attention Deficit Hyperactivity Disorder, Quantitative EEG features, Range EEG features, Functional connectivity features, Amplitude features, Spectral features
Epilepsy Detection from EEG Data Using a Hybrid CNN-LSTM Model

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Abstract:

‘An epileptic seizure’, a neurological disorder, occurs when electric burst travel over the brain, causing the person to lose control or consciousness. Anticipating epilepsy when the event happen is beneficial for epileptic control with medication or neurological pre-surgical planning. To detect epilepsy using electroencephalogram (EEG) data, machine learning and computational approaches are applied. Because of their better categorization skills, deep learning (DL) and machine learning (ML) approaches have recently been applied in the automated identification of epileptic events. ML and DL models can reliably diagnose diverse seizure disorders from vast EEG data and supply relevant findings for neurologists. To detect epilepsy, we developed a hybrid network that combines a 'Convolutional Neural Network (CNN)' and a 'Long Term Short Term Memory (LSTM)'. Our dataset is divided into two categories: epilepsy and normal. CNN-LSTM has been used to train our algorithm. With the Adam optimizer, our proposed CNN-LSTM model achieves 94.98 percent training accuracy and 82.21 percent validation accuracy. We also evaluate our results to those of machine learning methods such as Decision Tree, Logistic Regression and Naive Bayes. The comparative results clearly reveal that our suggested CNN-LSTM classifier outperforms the other learners.

Keywords:

Epilepsy detection, EEG, CNN-LSTM
Classifying Brain Tumor from MRI Images Using Parallel CNN Model

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Abstract:

Brain tumor, commonly known as intracranial tumor, is the most general and deadly disease which leads to a very short lifespan. It occurs due to the uncontrollable growth of cells which is unchecked by the process that is engaged in monitoring the normal cells. The survival rate due to this disease is the lowest and consequently the detection and classification of brain tumor has become crucial in early stages. In manual approach, brain tumors are diagnosed using (MRI). After the MRI displays the tumor in brain, the type of the tumor is identified by examining the result of biopsy of sample tissue. But having some limitations such as accurate measurement is achieved for finite number of image and also being time consuming matter, the automated computer aided diagnosis play a crucial rule in the detection of brain tumor. Several supervised and unsupervised machine learning algorithms have been established for the classification of brain tumor for years. In this paper, we have utilized both image processing and deep learning for successful classification of brain tumor from the MRI images. At first in the image preprocessing step, the MRI images are normalized and through image augmentation the number of images is enriched. Further the preprocessed images are passed through a parallel CNN network where the features of the images are extracted and classified. Our experimental result shows an accuracy of 89% that is promising.

Keywords:

Brain Tumor, Data Augmentation, Convolution Neural Network, Deep Learning
Triplet-loss based Siamese Convolutional Neural Network for 4-Way Classification of Alzheimer’s Disease

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Abstract:

Alzheimer’s disease (AD) is a neurodegenerative disease that causes irreversible damage to several brain regions including the hippocampus causing impairment in cognition, function and behaviour. Earlier diagnosis of the disease will reduce the suffering of the patients and their family members. Towards that aim, this paper presents a Siamese Convolutional Neural Network (CNN) based model using the Triplet-loss function for the 4-way classification of AD. We evaluated our models using both pre-trained and non-pre-trained CNNs. The models’ efficacy was tested on the OASIS dataset and obtained satisfactory results under a data-scarce real-time environment.

Keywords:

Structural Magnetic Resonance Imaging, Alzheimer’s Disease, Mild Cognitive Impairment, Triplet-Loss, Siamese CNN
Understanding Syntax Structure of Language after a Head Injury

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Abstract:
Cognitive-communication disorder is a type of language alteration generally associated with a traumatic brain injury, but could also be a sequelae from a disease. There is a latent possibility of establishing a connection between the ongoing epidemic language alterations sequelae with those reorganization in language after a head trauma that includes modifications in syntax production process. From a set of syntax indices previously elaborated to study language development, we propose a grammar-based analysis of such indices allowing a depiction in terms of a triangle-segmented polygon. A finding of the analysis is that the suggested context-free grammar gives the resources to have a suitable representation of the construction of the syntax production in individuals after a traumatic brain injury, in a post-recovery stage. The produced maps could serve to interpret how rules, when demanding more complexity, progress in contrast with a negative sample.

Keywords:
Cognitive-Communication Disorder, Traumatic Brain Injury Syntax, Context-Free Grammar, Triangle-Segmented Polygon Maps
Feature-selected Graph Spatial Attention Network for Addictive Brain-Networks Identification

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Abstract:

Functional alterations in the relevant neural circuits occur from drug addiction over a certain period. And these significant alterations are also revealed by analyzing fMRI. However, because of fMRI’s high dimensionality and poor signal-to-noise ratio, it is challenging to encode efficient and robust brain regional embeddings for both graph-level identification and region-level biomarkers detection tasks between nicotine addiction (NA) and healthy control (HC) groups. In this work, we represent the fMRI of the rat brain as a graph with biological attributes and propose a novel feature-selected graph spatial attention network (FGSAN) to extract the biomarkers of addiction and identify from these brain networks. Specially, a graph spatial attention encoder is employed to capture the features of spatiotemporal brain networks with spatial information. The method simultaneously adopts a Bayesian feature selection strategy to optimize the model and improve classification task by constraining features. Experiments on an addiction-related neural imaging dataset show that the proposed model can obtain superior performance and detect interpretable biomarkers associated with addiction-relevant neural circuits.

Keywords:

Neural Imaging Computing, Brain Networks, Graph Attention, Generative Deep Learning
Brain-Machine Intelligence and Brain-Inspired Computing

B207  Biologically Inspired Neural Path Finding

B215  A Second-Order Adaptive Social-Behavioural Model for Individual and Duo Motor Learning

B224  A Computational Neural Agent Model for the Role of Time Lags in Subjective Synchrony Detection and Related Behavioural Adaptivity

B240  Enhancing the MR Neuroimaging by Using the Deep Super-Resolution Reconstruction

B247  A Belief Rule Based Expert System to Diagnose Alzheimer’s disease Using Whole Blood Gene Expression Data
Biologically Inspired Neural Path Finding

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Abstract:

The human brain can be considered to be a graphical structure comprising of tens of billions of biological neurons connected by synapses. It has the remarkable ability to automatically re-route information flow through alternate paths, in case some neurons are damaged. Moreover, the brain is capable of retaining information and applying it to similar but completely unseen scenarios. In this paper, we take inspiration from these attributes of the brain to develop a computational framework to find the optimal low cost path between a source node and a destination node in a generalized graph. We show that our framework is capable of handling unseen graphs at test time. Moreover, it can find alternate optimal paths, when nodes are arbitrarily added or removed during inference, while maintaining a fixed prediction time. Code accompanying this work can be found here: https://github.com/hangligit/pathfinding.

Keywords:
Cognition, Path finding, Graphical Neural Networks
A Second-Order Adaptive Social-Behavioural Model for Individual and Duo Motor Learning

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Abstract:

This paper addresses computational analysis by psychological knowledge in motor learning of how people with certain personalities, alone and in pairs, are being influenced by several factors during their motor learning processes. To this end a second-order adaptive network model was designed for the social and behavioural processes involved. Example simulations show how the model fits to different situations. Mathematical analysis was performed for verification and parameter tuning for validation.
Becoming Attuned To Each Other Over Time: A Computational Neural Agent Model for the Role of Time Lags in Subjective Synchrony Detection and Related Behavioral Adaptivity

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Abstract:

Interpersonal synchrony usually means that people mutually adapt their behavior to each other over time. Such behavioral adaptivity is assumed to be driven by some form of subjective internal synchrony detection. In contrast to objective synchrony detection by an external (third-party) observer, subjective synchrony detection relies solely on information that is perceived by each of the synchronizing persons. Simultaneous actions of the two persons in principle cannot be sensed instantaneously by one of the two persons, but will involve time lags. These time lags reflect the time differences between a person’s own actions and the sensing of the actions of the other person. In the computational agent model described in this paper, we explore the role of time lags in different types of subjective synchrony detection and its involvement in behavioral adaptivity. Multiple simulation experiments show expected types of patterns of subjective time-lagged synchrony detection and related behavioral adaptivity.
Enhancing the MR Neuroimaging by Using the Deep Super-Resolution Reconstruction

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Abstract:

As brain investigation progresses, the need has become urgent from acquiring the higher resolution neuroimaging data to give a more detailed interpretation. In particular, the technological development and innovation of the Magnetic Resonance Imaging (MRI) machine, through increasing the magnetic field from low (such as 3T) to high (such as 7T), has revealed significant advantages regarding the image quality enhancement, etc. Currently, due to the limitations of hardware, physics and physiology, the large-scale acquisition of the high-resolution MRI neuroimages is still running on the road. Hence, enhancing the quality of the low-field MRI data is critical by using the advanced artificial intelligence technology. In this study, we propose a novel image enhancement framework, namely SR-MRI, trying to improve the quality of the low-resolution neuroimage: (1) combining with the Real-ESRGAN deep learning model; (2) bridging the 3T-MRI and the 7T-MRI within the same analysis scale; and (3) systematically comparing multiple evaluation indicators, including Brenner, SMD, SMD2, Variance, Vollath, Entropy, and NIQE. The experimental results suggest that the edge, fineness and texture features of the low-resolution neuroimages are restored to a great extent from the SR-MRI framework. In addition, the evaluation results of multiple indicators show that the processed 3T-MRI can achieve the similar effect from the 7T-MRI machine.

Keywords:

Magnetic Resonance Imaging (MRI), Super-Resolution, Brain Informatics, Deep Learning, Real-ESRGAN Model
A Belief Rule Based Expert System to Diagnose Alzheimer’s disease Using Whole Blood Gene Expression Data

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Abstract:
Alzheimer’s disease (AD) is a degenerative neurological disease that is the most common cause of dementia. It is also the fifth greatest reason for death in adults aged 65 and over. However, there is no accurate way of diagnosing neurological Alzheimer’s disorders in medical research. Blood gene expression analysis offers a realistic option for identifying those at risk of AD. Blood gene expression patterns have previously proved beneficial in diagnosing several brain disorders, despite the blood-brain barrier’s restricted permeability. The most extensively used statistical machine learning and deep learning algorithms are data-driven and do not address data uncertainty. Belief Rule-Based Expert System (BRBES) is an approach that can identify various forms of uncertainty in data and reason using evidential reasoning. No previous research studies have examined BRBES’ performance in diagnosing AD. As a result, this study aims to identify how effective BRBES is at diagnosing Alzheimer’s disease from blood gene expression data. We used a gradient-free technique to optimize the BRBES because prior research had shown the limits of gradient-based optimization. We have also attempted to address the class imbalance problem using BRBES’ consequent utility parameters. Finally, after 5-fold cross-validation, we compared our model to three classic ML models, finding that our model had a greater specificity than the other three models across all folds. The average specificity of our models for all folds was 32%.

Keywords:
BRBES, Alzheimer’s Disease, Gene Expression Data, Dis J uective BRBES, Class Imbalance
BI’22 Abstracts

(Peer-reviewed Abstracts)
**Peer-reviewed abstracts**

**B209**  Wireless Optogenetic Modulation of Neurons Enabled by Radioluminescent Nanoparticles

**B210**  Stability-Based Relative Clustering Validation for Data-Driven Stratification of Depressed Patients: A Structural Neuroimaging Study

**B211**  Identifying Suicide Attempters among Bipolar Depressed Patients using Structural Neuroimaging: a Machine Learning Study

**B212**  A Machine Learning Approach for The Prediction of Cognitive Impairment in Mood Disorders Using Multimodal Structural Neuroimaging

**B213**  A Machine Learning Pipeline for Efficient Differentiation between Depressed Bipolar Disorder and Major Depressive Disorder Patients Based on Structural Neuroimaging

**B223**  The Effect of Transcranial Electrical Stimulation on Sensorimotor Processing by Increasing Beta-Phase Synchronization Between Visual and Motor Areas
Wireless Optogenetic Modulation of Neurons Enabled by Radioluminescent Nanoparticles

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Abstract:
Despite the progress neuroscientists have made in understanding the function of neural circuits a comprehensive understanding of the human brain still remains an elusive goal. One of the most powerful methods of experimental and clinical neuroscience is deep brain stimulation (DBS). This method consists in the fact that some neurons of the brain are electrically stimulated for therapeutic or diagnostic purposes through electrodes inserted into the brain. An alternative to electrical stimulation is optogenetic stimulation, when photosensitive peptides are artificially expressed in brain cells using genetic engineering methods. This makes it possible to control neurons using light photons. But, optogenetic methods of neuron stimulation and inhibition requires cranial window or implantable fiber optics to deliver photons to a specific population of light-controlled neurons in the brain. The introduction of light guides into the brain, as well as electrodes, is associated with a number of problems and limits the application of this technique. We have developed and preliminarily tested a technology that could be of great importance in the clinical medicine. It was synthesized nanoparticles that convert X-rays into a visible light radiation and utilized them for in vivo optogenetic stimulation of brain neurons. Since X-rays easily pass through the brain tissue, we are now able to control neurons located in the deep brain structures non-invasively. A red-shifted channelrhodopsin (ReaChR) responding to light with wavelengths $\lambda \sim 590–630$ was expressed in pyramidal neurons of the mouse motor cortex (M1) using the AAV virus. Specially synthesized nanoparticles were injected into the same area of the cortex, and being biologically neutral, they remained in the brain tissue for several months. X-rays caused nanoparticles to glow, which in turn activated the ReaChR channel. This caused a depolarization of the membrane of targeted neurons and led to the activation of evoked potentials, which were recorded in vivo. The efficiency of neuron control using our technique was also tested by histological methods. This technology is as a great alternative for the deep brain stimulation (DBS), which is currently being widely used for the treatment of Parkinson’s disease (PD), epilepsy, and some other brain disorders. Being less traumatic and at least as effective as DBS. Moreover, it could be used for the therapeutic intervention in the wide range of other brain diseases, including, but not limited to epilepsy and essential tremor.

Keywords:
Brain Stimulation, Neurotechnology, Optogenetics, Nanoparticles, X-Ray
Stability-based relative clustering validation for data-driven stratification of depressed patients: a structural neuroimaging study

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Abstract:

Background: One of the main obstacles in providing efficient clinical management for bipolar (BD) and major depressive disorders (MDD) is clinical heterogeneity, whose biological underpinnings are not completely defined. A biologically meaningful stratification of depressed patients is needed to promote tailored diagnostic procedures. Here, we leverage a novel stability-based relative clustering validation procedure to unveil subgroups of depressed patients using structural neuroimaging data. The main advantage of this approach is the identification of the cluster solution that best generalizes, via supervised learning, on new data. Another concomitant objective is to investigate whether the selected clusters reflect subgroups of patients with distinct clinical signatures.

Methods: 317 depressed patients (112 MDD, 205 BD) underwent magnetic resonance scan to obtain T1-weighted and diffusion tensor images. Depressive symptomatology was assessed through Beck Depression Inventory–Short Form (BDI-SF) and Hamilton Depression Rating Scale (HDRS-21) in a subsample of 197 patients (69 MDD, 128 BD). We used both volume-based and surface-based regional measures of cortical and subcortical grey matter (GM) volumes (CAT12, FreeSurfer), and extracted tract-based fractional anisotropy (FA) white matter values (TBSS, FSL). Clustering analyses were performed through: kmeans with Euclidean distance; HDBSCAN with uniform manifold approximation and projection (UMAP) as preprocessing. Support vector machine (SVM) and elastic net logistic regression were considered as supervised classifiers. Each clustering-classifier combination was tested on: 1) volume-based; 2) surface-based; 3) volume-based, surface-based and FA measures combined. GM measures were adjusted for total intracranial volume. Clusters’ stability was assessed through 10x2 repeated cross-validation, iterating over 2-5 number of clusters for kmeans. SVM and elastic net hyperparameters tuning was performed with parallel grid search. Normalized stability (i.e., prediction error), silhouette and Davis-Bouldin scores were computed. Analyses were run with reval python package. To assess the clinical relevance of the best clustering solution, total scores and domains of BDI-SF (cognitive, behavioral, affective) and HDRS-21 (anxiety, depression, insomnia, somatic) were entered as dependent variables in MANOVA, considering clusters’ labels as fixed
factors. Chi-Square test was performed to investigate the proportion of BD and MDD patients among clusters.

**Results:** In all models, kmeans achieved more stable clustering solutions compared to HDBSCAN (normalized stability: 0.36-0.51 for HDBSCAN; 0.10-0.17 for kmeans). The best clustering-classifier combination was kmeans and elastic net using GM and FA measures, which identified 2 clusters with 0.10 normalized stability (silhouette score=0.16, davis-bouldin score=1.99). The features that best differentiated the clusters were right inferior frontal gyrus, temporal-occipital surface, posterior cerebellum, insula, and left anterior cingulate cortex. A significant between-clusters difference in BDI-SF and HDRS-21 scores was detected (F(9,187)=1.75, p=0.026), with a significant effect of cluster’s membership on BDI-SF cognitive dimension (F(1,195)=54.84, p=0.029). BD and MDD patients proportions did not differ by clusters (χ²(1, N=197)=2.17, p=0.178).

**Conclusions:** The stability-based cluster validation efficiently identified biologically and clinically meaningful subgroups of depressed patients beyond clinical diagnosis. This approach unveiled a distinct cluster of patients characterized by cognitive symptoms of depression, possibly linked to altered cortico-cerebellar connectivity. These findings foster the definition of new approaches for a data-driven stratification of psychiatric patients, paving the way to precision psychiatry.

**Funding:** GR-2019-12370616

**Keywords:**
Clustering, Precision Psychiatry, Depression, Bipolar Disorder, Neuroimaging
Identifying Suicide Attempters among Bipolar Depressed Patients using Structural Neuroimaging: a Machine Learning Study

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Abstract:

Background: Among psychiatric disorders, bipolar disorder (BD) is shown to be associated with the highest rate of suicide risk. Indeed, 30-50% of adults with BD attempt suicide at least once during their lifetime, and 15-20% of BD patients commit suicide. However, no objective and biological markers of suicidality are currently available, leaving clinical assessment based solely on subjective information. Thus, the identification of reliable biomarkers for suicidality in BD patients is crucial to improve suicide prevention in clinical practice and to move towards a precision medicine framework. The application of the machine learning (ML) approaches combined with neuroimaging techniques has been previously demonstrated successful in differentiating bipolar suicide attempters (SA) from non-attempters (nSA), achieving 84% of accuracy on functional connectivity data. However, no studies used structural neuroimaging to discriminate SA from nSA BD patients.

Aims: Given the ability of ML to manage high-dimensional data and to make predictions at the single-subject level, the present study aimed at applying ML on both white matter (WM) and grey matter (GM) voxel-wise data to assess their predictive power in differentiating bipolar SA from nSA.

Methods: 178 currently depressed BD patients (27 SA, 151 nSA) underwent an MRI session for T1-weighted and diffusion tensor images (DTI) acquisition. For GM volumes, T1-weighted sequences were pre-processed using Computational Atlas Toolbox 12 (CAT12) to obtain voxel-based morphometry (VBM) measures, whereas for WM measures, fractional anisotropy (FA) was computed through tract-based spatial statistics (TBSS) on FSL. Whole-brain VBM and FA measures were entered both separately and combined as input features into a Support Vector Machine (SVM), as implemented in the Pattern Recognition for Neuroimaging Toolbox (PRoNTo). All SVM models were trained to classify nSA vs. SA through a 5-fold nested cross-validation with subsampling, which allowed to calculate balanced accuracy (BA), specificity, sensitivity, and area under the receiver operator curve (AUC).

Results: The SVM model based on both GM and WM correctly classified SA and nSA with 59% of BA (47.33% nSA specificity, 70.67% SA sensitivity, 64% AUC). Conversely, the SVM model on GM reached a BA of 52% (36.67% nSA specificity, 67.33% SA sensitivity, 62% AUC), whereas the BA of the SVM model on WM was...
55.33% (66% nSA specificity, 44.67% SA sensitivity, 60% AUC). Conclusions. Although being above the chance level (i.e., 50%), the classification models achieved quite low accuracies in discriminating SA and nSA BD patients, which might be due to the imbalanced numerosity of the classes. However, despite these limits, our results highlight the importance of combining different kinds of information, since the model on both GM and WM was the most sensitive (70.67%) in identifying bipolar SA. Thus, future studies may consider including both structural and functional neuroimaging data to develop an objective and reliable predictive model to assess and hence prevent suicide risk among BD patients.

**Keywords:**

Bipolar Disorder, Suicide, Structural Neuroimaging, Machine Learning, Precision Psychiatry
A Machine Learning Approach for The Prediction of Cognitive Impairment in Mood Disorders Using Multimodal Structural Neuroimaging

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Abstract:

Background: Mood disorders are often characterized by cognitive impairment, which impacts on prognosis and quality of life. Thus, the identification of biomarkers for this facet could be useful to improve the health care of these patients. Several structural brain abnormalities have been related to cognitive dysfunctions in mood disorders at the group-level, limiting the translational impact of the findings in clinical practice. Machine Learning (ML) instead aims at predicting unseen observations at the single-subject level by handling multidimensional data, promoting the shift towards precision psychiatry. Hence, the present study aimed at assessing if structural neuroimaging data could identify patients with cognitive deficits using a ML approach.

Methods: 252 patients affected by bipolar (n=150) and major depressive disorder (n=102) underwent an MRI session for T1-weighted and diffusion tensor imaging acquisition, which allowed to calculate both grey matter voxel-based morphometry (VBM) through CAT12 and tract-based white matter fractional anisotropy (FA) measures. For all patients, verbal fluency (sample size: deficit=86; non-deficit=122), verbal memory (deficit=97; non-deficit=128), working memory (deficit=127; non-deficit=91), motor speed (deficit=112; non-deficit=86), attention and processing speed (deficit=147; non-deficit=65), and executive functioning (deficit=101; non-deficit=63) were assessed through the Brief Assessment of Cognition in Schizophrenia (BACS). Subject’s performance on BACS were corrected for age, sex, and education. Both support vector machine (SVM) and multiple kernel learning (MKL) models were trained entering voxel-wise VBM and FA measures combined as input features to discriminate patients with and without cognitive deficits in each domain. Models’ performance was assessed through a 10-fold nested cross-validation with subsampling, and significance was tested through 5000 random permutations setting the threshold to p<0.05.

Results: SVM outperformed MKL in all the domains, except for working memory and motor speed. Specifically, SVM reached a balanced accuracy (BA) of 63.47% (specific accuracy: non-deficit: 60.83%; deficit: 66.11%) in verbal fluency, BA of 57.50% (non-deficit: 55.48%; deficit: 59.52%) in attention and processing speed, and BA of 54.52% (non-deficit: 50.95%; deficit: 58.10%) in executive functions, BA of 48% (non-deficit: 47.67%; deficit: 48.33%) in verbal memory. Working memory and motor speed were predicted by MKL with a BA of 50.89% (non-deficit: 63.56%; deficit: 38.22%), and
54.44% (non-deficit: 55.56%; deficit: 53.33%), respectively. Only the model predicting verbal fluency was significantly different from null models (p=0.003).

**Conclusion:** Overall, SVM outperformed MKL in most cognitive domains, predicting cognitive deficits in major depressive and bipolar disorder patients. Although the tested models showed a classification performance just above the chance level, verbal fluency was predicted with good accuracy, and importantly it was based on meaningful information. Thus, although structural neuroimaging alterations have been previously associated with cognitive deficits, our results suggest that these features can only partially predict cognitive impairment in mood disorders at the single-subject level on out-of-sample observations. Nevertheless, the combination of these measures with other neuroimaging modalities and biological data might enhance the predictive power, elevating the ML approach as a promising framework for individual cognitive assessment, hence allowing tailored interventions to reduce the burden of these disorders.

**Funding:** Research activities are supported by the Italian Ministry of Health, GR-2018-12367789

**Keywords:**
Machine Learning, Bipolar Disorder, Major Depressive Disorder, Cognitive Deficits, Structural Neuroimaging
A Machine Learning Pipeline for Efficient Differentiation Between Depressed Bipolar Disorder and Major Depressive Disorder Patients Based on Structural Neuroimaging

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Abstract:

Background: Depression is the predominant mood alteration in bipolar disorder (BD), leading to overlapping symptomatology with major depressive disorder (MDD). Consequently, in clinical assessment, almost 60% of BD patients are misdiagnosed as affected by MDD. This calls for the creation of a predictive framework for the differentiation of BD and MDD patients based on reliable biomarkers. The machine learning (ML) framework appears to be particularly suitable for this task, given its ability to manage high-dimensional data and to make predictions at the single-subject level. Here, we implemented a ML-based predictive model for the differentiation between depressed BD and MDD patients based on structural neuroimaging features.

Methods: Diffusion tensor imaging (DTI) and T1-weighted MRI data were acquired for 285 depressed BD (n=182) and MDD (n=103) patients. DTI images were preprocessed via tract-based spatial statistics to extract fractional anisotropy (FA) maps, and voxel-based morphometry (VBM) measures were obtained from T1-weighted images using CAT12. The images were entered into a 5-fold nested cross-validated ML pipeline differentiating between BD and MDD patients, comprising: feature standardization, principal component analysis (PCA), and an elastic-net penalized regression. First, a cross-validated PCA was run to find the best number of components. The amount of variance to retain was varied (range: 50%-100%), and the value optimizing the performance of the downstream model was chosen. The regularization strength and the trade-off between L1 and L2 penalties of the elastic-net regularization were also tuned, and the loss was weighted according to class imbalance. The pipeline was run on FA, VBM, and their combination. The best model underwent 5000 random permutations as a test for significance, and the McNemar’s test was used to assess whether there was any significant difference between the models.

Results: The model with FA reached 78% overall accuracy (64% MDD specificity; 85% BD sensitivity), positive predictive value (PPV) of 81%, and negative predictive value (NPV) of 71%. The VBM model differentiated the classes with 61% accuracy (57% MDD specificity; 64% BD sensitivity), and 72% and 47% for PPV and NPV, respectively. Lastly, the combined model reached 71% of accuracy (59% MDD specificity; 77% BD sensitivity), 77% PPV, and 59% NPV. Permutation test on the FA-
based model revealed that it was significantly different (p<0.001) from null-models’
distribution. McNemar’s test showed that the FA-based model was significantly
different from the VBM (McNemar=18.08; p<0.001) and the combined
(McNemar=5.31; p=0.021) models. A significant difference was also found between
the combined and the VBM models (McNemar=0.011; p=0.011).

Discussion: In conclusion, our models differentiated between BD and MDD patients at
the single-subject level with good accuracy using structural MRI data. Particularly, FA
appeared to be the most informative measure, and its related model to be based on true
information, rather than chance. Interestingly, the combined model reached an
intermediate performance, which might be driven by some noise introduced in the
model by VBM features. Lastly, all the models were more prone to misclassify MDD
patients, possibly reflecting a high heterogeneity within the diagnostic group.

Funding: Research activities are supported by the Italian Ministry of Health, GR-
2018-12367789.

Keywords:

Machine Learning, Precision Psychiatry, Bipolar Disorder, Major Depressive Disorder,
Neuroimaging
The Effect of Transcranial Electrical Stimulation on Sensorimotor Processing by Increasing Beta-Phase Synchronization Between Visual and Motor Areas

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Abstract:

Previous studies have indicated that synchronized beta-band (14-30 Hz) oscillations in large-scale brain networks are associated with sensorimotor processing. Moreover, our previous study has shown that beta phase synchronization in a sensorimotor network is involved with sensorimotor learning, suggesting that increase in beta phase synchronization may enhance sensorimotor processing. However, little is known about the causal relationship between the change in beta phase synchronization and sensorimotor responses. Therefore, we attempted to enhance sensorimotor responses by modulating beta phase synchronization between visual and motor areas using transcranial alternating/direct current stimulation (tACS/tDCS). Therefore, we investigated whether modulating beta phase synchronization by applying tACS/tDCS over visual and motor areas would facilitate sensorimotor responses. During the task, participants were instructed to respond quickly (by button press) to a visual stimulus presented on a computer display (n=8). Task performance and electroencephalograph (EEG) data were recorded pre, during, and post stimulations for five conditions: alpha (10-Hz) tACS, beta (20-Hz) tACS, motor-anodal tDCS, visual-anodal tDCS, and a sham condition. The interval between conditions was created for at least a week to avoid practice effect. We hypothesized that both tACS/tDCS would increase beta phase synchronization between visual and motor areas and facilitate sensorimotor responses. The results showed the enhancing effect in sensorimotor responses, as response times were significantly shortened after stimulation, however only under motor-anodal tDCS condition. EEG time-frequency analysis showed significant increases in beta phase synchronization between motor and visual areas, following motor-anodal tDCS. Increases in beta-phase synchronization were significantly correlated with decreases in response times after motor-anodal tDCS. These findings confirm the association between beta phase synchronization and sensorimotor processing and, furthermore, suggest anodal tDCS as a possible method for enhancing sensorimotor processing.

Keywords:

EEG, Synchronization, tDCS, tACS, Sensorimotor
BI’22 Abstracts
(Workshop /Special Session)
Special Session on Cutting Edge Technologies for Human-Computer Interaction

B219   EEG Signal Classification Using Shallow FBCSP Convnet with a New Cropping Strategy
EEG Signal Classification Using Shallow FBCSP Convnet with a New Cropping Strategy

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Abstract:

Raw EEG signal is dynamically collected from electrode channels distributing on the scalp surface and stored in computers as a 2D array of electrode channel (space) and time. In the past, most experiments were based on pure 2D EEG signal array of space and time. Shallow FBCSP ConvNet⁵ is one of the successful models in handling 2D EEG signal array, which comes from FBCSP algorithm⁴, a widely used algorithm in EEG decoding. With an original cropping strategy, Shallow FBCSP ConvNet reaches a high accuracy in EEG signal classification. In this paper, we propose a new cropping strategy to generate 3D EEG signal array of space, time and cropped piece. With redesigning the existing 2D Shallow FBCSP ConvNet model to become a 3D model, we obtained a good experimental result.

Keywords:

2D EEG Signal, Shallow FBCSP Convnet, Cropping Strategy, 3D Array
Detection of Healthy and Unhealthy Brain States from Local Field Potentials using Machine Learning
Detection of Healthy and Unhealthy Brain States from Local Field Potentials using Machine Learning

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Abstract:

Neural signals are the recordings of the electrical activity individual or groups of neurons, and they are used for disease staging, brain-computer interface control and understanding the neural processes. When carrying out a functional connectivity study in rodents, processing must be done to eliminate disturbance in the data in order to have the most faithful representation of the neural activity. This step mainly includes filtering and artefact removal, where the latter can be approached by diverse methods. Furthermore, it is important to identify when the rodent is stressed, as the local field potentials can be coupled to theta oscillations. To this end, we set out to develop a machine learning-based model for the detection of stress in rodents with multi-modal recordings, namely local field potentials, respiration and electrocardiography. We explore subject-specific and cross-subject models, as well as employing an artefact detection model as a generic anomaly detector. Results show that subject-specific models can achieve a good performance, but the variability is significant across all three signals among rodents of the same age, gender and species.

Keywords:

Computational Neuroscience, Machine Learning, Physiological Signals
The 2nd Workshop on Internet Adaption and Mental Health

S05201 An Internet-Based Study on the Mental Health of Postgraduate Tutors: Influenced by the Perceived Social Support, Psychological Capital, and Mentoring Relationship

S05203 The Relationship between Media Multitasking and Creativity: A Moderated Mediation Model

S05204 The Effect of Priming Types and Construal Levels on College Students' Composite Money-Environment Risky Decision-Making

S05205 The Association Between Dormitory Relationship and Non-suicidal Self-injury in Chinese University Students: A Moderated Mediation Model

S05206 Public Stereotypes toward People with Physical and Mental Disabilities

S05207 A Path Model of Psychological Factors for Chinese College Students’ Gullibility To Telecom Fraud

S05208 An Internet-Based Study on the Mental Health Assessment of Juvenile Involved in Crime and Psychological Factors for Juvenile Delinquency

S05209 The Low-Intensity Online Meaning-making Intervention Promotes Stress-Related Growth: A Randomized Controlled Trial study
An Internet-Based Study on the Mental Health of Postgraduate Tutors: Influenced by the Perceived Social Support, Psychological Capital, and Mentoring Relationship

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Abstract:

The mental health of postgraduate tutors is not only related to their own personal development, but also affects the quality of college education and the psychological status of graduate students. Therefore, it is necessary to study the mental health of postgraduate tutors and the influencing factors, but few existing studies have focused on this issue. The purpose of the present study is to explore the mechanism of how the social support, psychological capital, and mentoring relationship influence the mental health of postgraduate tutors, and build a model to conceptualize the principles on how to improve the mental health of tutors. All the data were collected via an Internet platform developed by our group. The whole study was divided into two parts: (1) preparing a questionnaire for measuring the mentoring relationship; (2) using the Symptom Checklist-90 (SCL-90), the Perceived Social Support Scale (PSSS), the Mentoring Relationship Questionnaire, and the College Teacher Psychological Capital Questionnaire to collect data reflecting different aspects of the mental health of postgraduate tutors, and then construct the statistical model. The results showed that: (1) the mentoring relationship questionnaire was composed of three dimensions: mentoring interaction, relationship intimacy and interpersonal network; the variance explained rate was 55.512%, and the Cronbach's alpha coefficient was 0.869; (2) the perceived social support and psychological capital significantly predicted Mentor's mental health; (3) psychological capital played a significant mediating role between perceived social support and mental health, and the mentoring relationship moderated the impact of perceived social support on psychological capital and mental health. Our findings demonstrated that after feeling the support of the surrounding environment, postgraduate tutors can enhance their psychological capital and improve their mental health.

Keywords:

Postgraduate Tutors, Mental Health, Mentoring Relationship, Perceived Social Support, Psychological Capital
The Relationship Between Media Multitasking and Creativity: A Moderated Mediation Model

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Abstract:
Media multitasking, which refers to simultaneous processing or frequent switching to perform multiple different media or non-media tasks, is used by 60.3% of Chinese adolescents in their daily lives, which means that media multitasking has become a new norm in the media use of contemporary youth. In recent years, the relationship between media multitasking and individuals' cognitive abilities has received much attention, especially in relation to creativity. However, its internal mechanisms are unclear. The present study examines the relationship between media multitasking, cognitive flexibility, self-transcending life meaning, and creativity in adolescents through a cross-sectional study with a large sample. The Media Multitasking Scale (MMS), Cognitive Flexibility Scale (CFS), Self-Transcending Meaning of Life Scale (STML), and Creativity-Drawing Test (TCT-DP) were administered to 1158 middle school students (age: 12-17; male: 582; female: 576) in a middle school in Yingtan, Jiangxi Province. The results showed that (1) media multitasking was significantly related to cognitive flexibility, self-transcendent life meaning, and creativity; (2) media multitasking was not a significant direct predictor of creativity; (3) media multitasking significantly predicted cognitive flexibility and cognitive flexibility significantly predicted creativity, i.e., cognitive flexibility had a fully mediating role in the relationship between media multitasking and creativity; (4) self-transcendent life meaning moderated the relationship between cognitive flexibility and creativity. The present study found that adolescents' cognitive flexibility fully mediated the relationship between media multitasking and creativity, and this mediating process was moderated by self-transcendental meaning, i.e., the effect of adolescents' media multitasking on creativity was moderated by the mediating effect.

Keywords:
Media Multitasking, Creativity, Cognitive Flexibility, Self-Transcending Meaning of Life
The effect of priming types and construal levels on college students' composite money-environment risky decision-making

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Abstract:
In the context of green economy development, the study of the composite money-environment risky decision-making has important practical significance, which could help to study the circumstances under which individuals value environmental benefits more and provides a reference for the relevant authorities to formulate environmental protection policies. The present study randomly selected 94 college students as subjects, used 2×3 two-factor mixed experimental design, and explored the impact of different priming types and construal levels on the composite money-environment risky decision-making through the combination of investigation and experiment methods, which will enrich the research’s results in the field of composite money-environment risky decision-making. The results showed that: (1) The main effect of priming types on composite money-environment risky decision-making was significant. Compared with the type of neutral priming, the participants in the money priming, individuals tended to give higher weight to the monetary gains in the compound option; the participants in the environmental priming tended to give higher weight to the environmental gains in the compound option; (2) The main effect of construal levels on composite money-environment risky decision-making was significant. Those of the high construal level group gave higher weight to the environmental gains than those of low construal level group; (3) The interaction between the priming types and construal levels was significant. From this, it could be concluded that both the types of priming and the levels of construal had an impact on the composite money-environment risky decision-making, and the effect of the levels of construal on composite money-environment risky decision-making would vary with the types of priming.

Keywords:
Priming Type, Construal Level, Decision-Making, Money Priming, Environmental Priming
The Association Between Dormitory Relationship and Non-suicidal Self-injury in Chinese University Students: A Moderated Mediation Model

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Abstract:
Dormitory relationship is an important microenvironment for university students. A large number of studies in recent years have found their impact on the mental health status of university students. Based on the “interpersonal theory of depression” and the “two-dimensional four-function model of non-suicidal self-injury”, interpersonal relationships (i.e. dormitory relationship) could predict university students’ depression and subsequently non-suicidal self-injurious behavior. According to the “relationship development system theory”, dormitory relationship and parent-child relationship would play an interactive role in the development of non-suicidal self-injury, and together with the compensatory effect of parent-child relationship on dormitory relationship, parent-child relationship could play a moderating role between dormitory relationship and non-suicidal self-injury. Also, parent-child relationship is one of the protective factors for non-suicidal self-injury and may moderate the predictive effect of depression on non-suicidal self-injury. In other words, the predictive effect of depression on non-suicidal self-injury and the predictive effect of dormitory relationships on non-suicidal self-injury were particularly stronger for university students from families with poor parent-child relationships. To investigate the relationship among dormitory relationship, non-suicidal self-injury, depression and parent-child relationship, nine hundred and forty-two Chinese university students (Mage = 20.89 ± 1.89 years old) participated in this study. Results revealed that: (1) dormitory relationship had a negative predictive effect on non-suicidal self-injury; (2) depression played a partial mediating role in the relationship between dormitory relationship and non-suicidal self-injury; and (3) the direct and indirect effects were moderated by parent-child relationship, which meant that the effect of dormitory relationship on non-suicidal self-injury can differ depending on the parent-child relationship of students. Besides, both the effects were stronger for individuals with worse parent-child relationship. Our findings highlighted the impact of dormitory relationship and the critical role of depression in students’ non-suicidal self-injury, especially for the Chinese university students from bad parent-child relationship.

Keywords:
Dormitory Relationship, Non-Suicidal Self-Injury, Depression, Parent-Child Relationship, Chinese University Students
Public Stereotypes toward People with Physical and Mental Disabilities

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Abstract:
Public prejudice, discrimination, and stigma against persons with disabilities make it difficult for them and their families to integrate into society. Stereotypes are seen as the first stage of prejudice, discrimination, and stigma. In order to help people with disabilities integrate into society better and faster, this research explores the public stereotypes toward people with physical and mental disabilities.

Methods: Free association and semantic difference scale were used to explore the public explicit stereotypes toward people with disabilities. 35 subjects were recruited in the stage of trait words collection. In the scale preparation stage, 567 valid questionnaires were collected. In the formal testing stage, we compared the explicit stereotypes toward the physical disability group, the mental disability group, and the normal group using a self-designed scale. 257 valid questionnaires were collected.

Results: (1) A semantic difference scale with good reliability and validity was developed to measure explicit stereotypes toward people with physical and mental disabilities. (2) Compared with the normal group, we found that the public impression of people with physical and mental disabilities was more negative. (3) Comparing the two groups of people with disabilities, we found that the public had a more negative impression of people with mental disabilities than people with physical disabilities. (4) People with physical disabilities were considered more "respectable" than people without disabilities. Compared with people with physical disabilities, the public thought people with mental disabilities were more "rich" and "confident".

Conclusions: The public has negative stereotypes toward people with disabilities. Public stereotypes toward people with mental disabilities are more negative than those with physical disabilities. But on some certain traits, the public also has a more positive impression of people with disabilities than people without disabilities, and a more positive impression of people with mental disabilities than people with physical disabilities.

Keywords: Explicit Stereotypes, Physical Disabilities, Mental Disabilities
A Path Model of Psychological Factors for Chinese College Students

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Abstract:

In recent years, telecom fraud has been a high trend in the Chinese college student population, which has seriously endangered students’ property security. To carry out fraud prevention efforts more accurately, this study focused on the susceptibility-to-persuasion. Taking the gullibility as an entry point, we reveal the psychological factors and relationship paths that affect the gullibility of Chinese college students. To achieve these purposes, this study is divided into three sub-studies. Study 1 explored the structure of college students’ susceptibility-to-persuasion and revised the college students’ susceptibility-to-persuasion scale. 790 Chinese college students were selected as subjects in two groups to develop a formal 30-item scale measuring seven dimensions of sensation seeking, self-control, social influence, risk preference, advertising attitude, cognitive need, and uniqueness choice. The scale had good reliability and validity (Cronbach α = 0.84, RMSEA = 0.06, CFI = 0.90, TLI = 0.89, χ2/df = 3.04), which provided instrumental support for Study 2 and Study 3. Study 2 was based on study 1 and used an experimental approach to investigate the relationship between susceptibility-to-persuasion and the gullibility to messages. The independent variables were susceptibility-to-persuasion score (high/low) and scam situation (benefit situation/information situation), and the dependent variable was whether to be gullible to text messages. 60 Chinese college students were selected to participate in the experiment, and the results of the study showed that college students in the high susceptibility-to-persuasion group were more likely to be gullible to messages [OR = 1.28, 95% CI (1.10, 1.48)] and that the information situation was more deceptive to college students than the benefits situation [OR = 0.03, 95% CI (0.002, 0.35)]. Study 3 in order to investigate the psychological factors and relationship paths of Chinese college students’ gullibility, 1153 college students from 597 colleges across China were selected for the study. The susceptibility-to-persuasion scale, gullibility questionnaire, feelings of inadequacy scale, and emotional social loneliness inventory were used as instruments. The results showed that 1. The total score of susceptibility-to-persuasion of college students could positively predict the gullibility (β = 0.41, p < 0.001); 2. The susceptibility-to-persuasion mediated the effect of inferiority feelings on the gullibility, which accounted for 68.36% of the total effect; 3. This process was moderated by loneliness. The main findings of this study are: The susceptibility-to-persuasion scale includes 7 dimensions and meets the psychometric requirements. College students’ inferiority feelings can predict their gullibility through the degree of susceptibility-to-persuasion, and low loneliness can effectively moderate the predictive effect of the degree of susceptibility-to-persuasion on the gullibility.

Keywords:
Telecom Fraud, Gullibility, Susceptibility to Persuasion, Inferiority Feelings, Loneliness
An Internet-Based Study on the Mental Health Assessment of Juvenile Involved in Crime and Psychological Factors for Juvenile Delinquency

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Abstract:
With the increasing rate of juvenile delinquency year by year, the support, education and correction of juveniles involved in crime and the prevention of juvenile delinquency have received attention by researchers in this field. Previous studies have focused on the behavioral intervention of juveniles involved in crime, but less attention has been paid to the psychological factors that affect juvenile delinquency. The present study aims at exploring the psychological factors that affect juvenile delinquency, constructing a mental health assessment tool for juveniles involved in crime, and putting forward a psychological direction of juvenile delinquency's support, education and correction, and making suggestions for preventing juvenile delinquency. This study develops an assessment tool for the mental health level of juvenile involved in crime, which consisted of ten parts, including nine dimensions of SCL-90, psychological capital, self-control, coping style, seven-factor personality, moral identity, empathy, family support, and adolescent life events and The House-Tree-Person (H-T-P) Test. The tool was posted to both juveniles with criminal records and juveniles without criminal records. In order to reduce the evaluation error caused by subjective factors, all the data were collected and assessed via an mental health evaluation Internet platform. The results showed that: (1) the assessment tool could accurately assess the mental health of juveniles involved in crime; (2) conscientiousness, emotional stability, and wisdom in the personality dimension, coping style, personality dimension, moral identity level and youth life events could significantly predict youth delinquency. Our findings demonstrated that some dimensions of juveniles' mental health can predict criminal behavior; lower self-evaluation, more negative coping styles, less responsibility, more emotional instability, lower intelligence, lower moral identity, and more vulnerable adolescents affected by negative life events are more likely to commit criminal behavior.
The Low-Intensity Online Meaning-making Intervention Promotes Stress-Related Growth: a Randomized Controlled Trial study

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Abstract:

Recent research on stress has gradually shifted from a previous disease-oriented approach to a health-oriented approach. Studies have shown that not everyone suffering from stress are likely to result in dysfunction, and in some circumstances, stress can even bring about positive effects and stress-related growth, with meaning-making being one of the important mechanisms. Meaning-making is a form of coping strategy that aims to change the way individuals assess situations and better align their beliefs, goals, and stressful situations, which can help individuals better cope with stress and achieve stress-related growth. However, efforts on meaning-making interventions to promote stress-related growth under stress was scare and necessary. The present study conducted a low-intensity online meaning-making intervention to enhance stress-related growth. This study verified the effectiveness of the intervention through a 7-day low-intensity online intervention for meaning-making using a randomized controlled trial. The study was a 3 (Time: pre-test vs. post-test vs. follow-up) × 2 (Group: meaning-making intervention group vs. waiting list) mixed experimental design in which 230 college students were randomly assigned to an intervention and a waiting list group. A total of 76 participants completed the pre and post-test, follow-up, and 7-day online intervention and 78 participants completed the pre and post-test and follow-up in the waiting list. For ethical reasons, subjects in the waiting list group also received a 7-day online intervention for the meaning-making after all measurements were completed. The 7-day intervention consisted of psychoeducation on meaning making, application of skills for meaning making under stress, and a photographic intervention lasting 7 days. The results of the pre- and post-tests indicated an immediate effect of the intervention, with significant time and group interactions when the dependent variables were positive emotions, meaning-making, and stress-related growth after controlling for gender, age, and sense of meaning in life on the pre-test, with \( \eta^2_p \) ranging from 0.028 to 0.046. The intervention group had significantly higher levels of positive emotions, meaning-making, and stress-related growth in the post-test with large effect sizes, and the waiting group also had a small yet significant increase on positive emotions and meaning. The promoting effects on positive emotions, meaning-making, and stress-related growth were maintained in the intervention group at the 1-month follow-up. Meaning-making could mediate the effect of daily perceived stress and negative life stress on the change in stress-related growth.

Keywords:

Meaning-Making, Stress-Related Growth, Low-Intensity Online Intervention, Randomized Controlled Trial
The 4th International Workshop on Cognitive Neuroscience of Thinking and Reasoning

S09201 Cognitive bias of trait anxiety individuals towards negative facial expression recognition: Based on attentional blink effect

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S09205 Dissociation between proactive and reactive control: Evidence from pupillometry

S09208 Research on conjunction fallacy based on dual process theory
Cognitive Bias of Trait Anxiety Individuals Towards Negative Facial Expression Recognition: Based on Attentional Blink Effect

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Abstract:

Objectives: Trait anxiety is a kind of personality trait, also known as a comparatively steady and lasting individual tendency towards anxiety. Previous studies show that high trait anxiety individuals are more likely to experience strong intensity of tension and dysphoric mood confronting stressful situations, for they had certain negativity bias in attention, memorizing and other cognitive processes relative to the low anxiety ones. Because of the accurate mechanism of this negativity bias among people with high level of anxiety still remaining to be specified, this study aims to investigate differences of selective attention among individuals of high and low trait anxiety towards emotional facial expressions from a temporal dimension.

Methods: Distributed State-trait Anxiety Scale among college students choosing the top and the last 25% of the students in ranking according to their scores as the high and low anxiety group. Adopted a 2 (level of anxiety: high, low) × 2 (type of task: single, dual) × 4 (SOA: 0ms, 235ms, 706ms, 1176ms) design for four experiment using simple two-target paradigm to explore AB differences between high and low anxiety group. There were four experiments setting four target combinations (T1, T2) respectively: Experiment 1 negative-positive facial expressions then Experiment 2: negative-positive, Experiment 3: negative-neutral and Experiment 4: neutral-negative.

Results: (1) Under the condition of facial expression as negative-positive, type of task presented significant simple effect when SOAs are 0ms, 235ms and 706ms (F(3, 138) = 9.82, p = 0.003; F(3, 138) = 12.61, p = 0.001; F(3, 138) = 5.38, p < 0.05 ) among the high anxiety group. There was simple effect when SOAs were 0ms and 235ms (F(3, 138) = 6.81, p = 0.005; F(3, 138) = 6.78, p < 0.05) among the low anxiety group. Post hoc tests showed an identical discrimination between single and dual task among the high anxiety group upon every level at SOAs (p < 0.001) and a marginally significant effect between these two tasks among the low anxiety group upon every level at SOAs (p = 0.060). (2) Under the condition of facial expression as neutral-negative, type of task presented significant simple effect when SOAs were 706ms and 1176ms (F(3, 138) = 6.40, p < 0.05; F(3, 138) = 14.04, p < 0.001). Post hoc tests showed a marginally significant effect between single and dual task among the high anxiety group upon every level at SOAs (p = 0.060) and an identical discrimination between these two tasks among the low anxiety group upon every level at SOAs (p < 0.001).
**Conclusions:** The internal mechanism of attentional blink among individuals of high level of anxiety is the deficits in distinguishing negative expressions precisely. Neutral faces provide an antagonistic effect of attentional blink and a probable priming effect on identifying following negative emotional faces among the low anxiety group when served as background.

**Keywords:**

Trait Anxiety, Attentional Blink (AB), SOA, Pictures of Facial Expressions, Emotion
The Relationship Between Creativity and Deductive Reasoning: The Role of Executive Function

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Abstract:

Creativity and deductive reasoning are both important higher cognitive functions of the human brain and are generally considered to be distinct thinking patterns: illogical processing vs. deductive reasoning. Logical processing, some recent studies suggest that they are closely related, but the cognitive mechanisms of creativity and deductive reasoning are still unclear. In order to solve this problem, we will combine behavioral and transcranial direct current stimulation (tDCS) techniques to explore the cognitive mechanisms of creativity and deductive reasoning from the perspective of executive function. In experiment 1, we analyzed the effects of working memory, inhibitory control and cognitive flexibility on creativity and deductive reasoning from the perspective of executive function. The results showed that working memory, dominant response inhibition and cognitive flexibility significantly predicted creativity task performance. Working memory and dominant response inhibition significantly predicted deductive reasoning performance. Further analysis showed that working memory and dominant response inhibition could explain the correlation between creativity and deductive reasoning. In experiment 1, the effect of distraction inhibition on creativity and deductive reasoning was not found, which may be related to the ceiling effect in participants' performance in distraction inhibition task. Therefore, experiment 2 further explored the effect of distraction inhibition on creativity and deductive reasoning. The results showed that divergent thinking performance improved and deductive reasoning performance decreased under high distraction inhibition. Experiment 3 Further explored the cognitive mechanism of creativity and deductive reasoning with the help of tDCS technology. TDCS was used to stimulate the right inferior frontal gyrus (target F8) and the left inferior frontal gyrus (target F7), respectively. Creativity task, deductive reasoning task, dominant response suppression task and distraction suppression task were performed simultaneously. The results showed that inhibition of the left inferior frontal gyrus decreased distraction inhibition and deductive reasoning performance, but increased creativity performance. The inhibition of distraction partially mediated the relationship between left inferior frontal gyrus and creativity. Distractor inhibition partially mediated the relationship between left inferior frontal gyrus and deductive reasoning. Excitation of the right inferior frontal gyrus can improve the performance of dominant response inhibition, creativity and deductive reasoning. Inhibition of dominant response partially mediated the relationship between right inferior frontal gyrus and creativity. Dominant response inhibition was a complete mediator between right inferior frontal gyrus and deductive reasoning. In conclusion, this study suggests that creativity and deductive reasoning are closely related higher cognitive functions, and that working memory of executive function and inhibition of dominant response may explain the correlation between
creativity and deductive reasoning. Distraction inhibition can promote deductive reasoning performance, but reduce creativity performance; Meanwhile, cognitive flexibility only predicted creativity, but not deductive reasoning.

**Keywords:**

Creativity, Deductive Reasoning, Executive Function, Inhibitory Control
Evidence in Support of Analogical Reasoning Improvements with Executive Attention Intervention in Healthy Young Adults

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Abstract:

Analogical reasoning (AR) improvement is important in the educational outcome improvement. Inspired by recent ideas and evidence, we adopted anti-saccade task training as executive attention (EA) intervention and tested whether it could improve AR performance. Serial-task paradigm was employed where participants should perform the anti-saccade task and the AR task including a perception condition sequentially. The experimental group (n=37) finished the anti-saccade task of which the ratio of anti-saccade trials to pro-saccade trials was 5:1 while the counterpart was 1:1 in the active control group (n=36). Also, a blank control group (n=100) was established where participants merely finished the AR task. The event-related electroencephalographic data were recorded when participants were performing the EA and AR tasks. Additionally, their resting state electroencephalographic was collected before and after EA intervention respectively. Behaviorally, the experimental group reacted significantly faster than other two groups in AR but not in perception. At neural level, in the experimental group merely, the anti-saccade trials elicited smaller N2 than pro-saccade trials and the resting alpha power was improved after EA intervention. No significant difference of P2 was found between two groups in AR or perception but the experimental group showed a larger late positive component than the active control group in AR. We also found that the late positive component mediated the relationship between the N2 of anti-saccade trials and AR react times in the experimental group. We suggested that the core cognitive mechanism was to strengthen the response pattern of interference suppression and voluntary attention shift, which helped the subjects to better integrate information when solving reasoning problems, so as to solve the problem smoothly, which may pave the way for future reliable fluid intelligence improvement.

Keywords:

Analogical Reasoning (AR), Executive Attention (EA), Cognitive Intervention, Anti-Saccade Task, Electroencephalographic
Dissociation Between Proactive and Reactive Control: Evidence from Pupillometry

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Abstract:

The dual mechanisms of control (DMC) framework proposes that people tend to employ one of two different strategies to deal with cognitive tasks: reactive or proactive control. Previous studies have found that proactive and reactive control exhibit different behavioral performance in different tasks, as well as pupillary responses. Although pupillary changes under different control modes are consistent with behavioral performance, the correlation between pupillary responses and behavioral performance under different control modes has not yet been definitively demonstrated. The present study aimed at getting more insight in the pupillary responses of proactive and reactive control and their relationship with cognitive control task performance. Participants were instructed to respond to the meaning of the word or the gender of the face according to the pre cues in the Stroop task switching, pupil and behavioral data from 38 participants were recorded and analyzed. We observed larger cue-locked task-evoked pupillary responses (TEPR) for trials in task switch than task repetition, which reflect the increasing proactive cognitive control of processing switching cue. We also found target stimuli-locked TEPR on incongruent trials was larger than those on congruent trials, which reflects the inhibition process of increasing Stroop conflict when processing face-word incongruent stimuli. In the subsequent response-locked period, we found larger response-locked TEPR in switch as compared to repeat trials, and in incongruent as compared to congruent trials, indicating the increase of reactive cognitive control caused by task-set interference and response conflict in the reaction selection stage. The correlation analysis of pupillary response and reaction time (RT) shows that cue-locked TEPR is negatively correlated with RT and switch cost in terms of RT, and response-locked TEPR is positively correlated with RT and Stroop effect in terms of RT. There is no correlation between cue-locked TEPR and response-locked TEPR. These results indicate that pupillometry can effectively separate proactive and reactive control in the same trial task, and individual performance differences in cognitive control are related to the differences in the magnitude of TEPR. The mechanism may be the changes of activity in different brain regions mediated by LC-NE.

Keywords:

Cognitive Control, Stroop Conflict, Task Switching, Pupillary Responses, Baseline Pupil Size
Research on Conjunction Fallacy Based on Dual Process Theory

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Abstract:
In probability judgment tasks, human’s judgment don't always rely on the principle of probability, but is influenced by specific contexts and situations. When the objective probability rule (conjunction rules: \(P(A \cap B)<P(A)\) or \(P(B)\)) is ignored, and the combination of two events that conform to subjective expectations is considered to have a higher probability of occurrence, this phenomenon is called the conjunction fallacy. A lot of researches focus on how to explain and how to avoid the conjunction fallacy. The dual process theory is proposed as an important theory to explain the phenomenon of conjunction fallacy. The theory holds that system 1, which is related to belief processing, proposes wrong answers, and it is not suppressed in the conflict of correct answers of system 2, which is related to logical rules, so the phenomenon of conjunction fallacy occurs in reasoning judgments. But there is still little evidence to support this theory. To this end, this study used the classic conjunction fallacy probability judgment task to further verify this theory through two behavioral experiments and transcranial direct current stimulation (tDCS) technology while exploring effective ways to avoid conjunction fallacy. Experiment 1 recruited 30 participants to explore the effect of conjunctive fallacy on individual differences in cognitive reflection ability (Cognitive Reflection Test scores) and intelligence (Raven Matrices scores). The results showed that the conjunction fallacy was unrelated to the participants' cognitive reflection ability, and the cognitive reflection test score was unrelated to the accuracy rate and response time of conflict conditions in the probabilistic judgment task. There is no significant correlation between the conjunction fallacy and the participants' accuracy, but almost significant negative correlation with the response time. Experiment 2 examined whether logical clue would affect conjunction fallacy by comparing the performance of 60 participants in probability judgment task with and without clues. The results showed that the "clue" condition was significantly more accurate than the "no clue" condition in all material types, and the response time was significantly shorter, indicating that the logical clue can make it easier for participants to activate system 2 during the task to judge correctly. Experiment 3 used tDCS to target anodal stimulation of the left inferior frontal gyrus(IFG) related to belief processing, the right inferior frontal gyrus(IFG) related to inhibitory control, and sham stimulation to access the effect of activation of the right and left inferior frontal gyrus on the conjunction fallacy. The results showed that the experimental group that received anodal tDCS to the right IFG significantly improved accuracy in "conflict" condition, relative to sham stimulation, indicating that the inhibition of system 1 was strengthened; the experimental group that received anodal tDCS to the left IFG significantly reduced reaction time in "conflict" condition, relative to sham stimulation, indicating that system 1 has been strengthened, supporting the dual process theory of the conjunction fallacy.
fallacy. In summary, this paper further verifies the dual process theory of conjunction fallacy based on two behavioral experiments and one tDCS experiment.

**Keywords:**

Conjunction Fallacy, Dual Process Theory, Cognitive Reflection Ability, Logical Training, tDCS