第八届全国脑电与脑成像研究与应用研讨会

论 文 集

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目录

Theta oscillations in prolactinomas: Neurocognitive deficits in executive controls.....1
Mapping Between Scalp Low-frequency EEG Rhythms and Current Source in Deep Brain.....3
Altered resting-state functional connectivity within medication-naïve children with attention deficit hyperactivity disorder.....4
Aberrant reward dynamics in depression with anticipatory anhedonia..... 6
Emotion recognition based on TQWT-BGWO and EEG.....7
共情关怀对公平决策的影响——来自 ERP 的证据.....10
Social value orientation modulates fairness processing during social decision-making: evidence from behavior and brain potentials.....11
个体内高度的静息态变异性与更好的认知控制有关:来自 STROOP 任务的证据13
经颅直流电刺激左侧初级运动皮层对言语智力的影响.....14
The semantic priming of emotional concept on bodily expressions..... 15
Research on the Stroke Risk Prediction Based on the Fused Feature of EEG Data.... 17
A Human-Autonomous Vehicle Interaction Platform Based on Apollo-LGSVL Co-simulation System with EEG Acquisition.....19
The hierarchical sensitivity to social misalignment during decision-making under uncertainty.....21
Robust and reliable implicit categorization of food information and its healthfulness but not tastiness at the individual level through EEG frequency tagging..... 23
人类社会沟通系统的产生及其脑-脑机制的研究.....25
Gender differences in the effect of perceived stress on brain morphology.....26
Attention modulation on the perception of others' vocal pain..... 28
Brain gray matter structures associated with trait impulsivity: A systematic review and voxel-based meta-analysis.....30
Cooperate or aggress? An opponent's tendencies modulate the neural dynamics of interpersonal cooperation..... 32
Independent syntactic representation identified in left front-temporal cortex during Chinese sentence comprehension.....35
Myeloarchitectonic asymmetries of language regions in the human brain.....37
Acupoint-brain (acubrain) mapping: Common and distinct cortical language regions activated by focused ultrasound stimulation on two language-relevant acupoints..... 39

Superior emotional regulating effects of creative cognitive reappraisal: An ERP Study42
Acute stress changes the computational substrates of unaffected third parties.....43
Event-Related Potential Evidence of Audiovisual Benefit Effect of Lexical Tone in Mandarin..... 45
Therapeutic efficacy of connectivity-directed transcranial magnetic stimulation on anticipatory anhedonia..... 47
Downregulated GPR30 Expression in the Epileptogenic Foci of Female Patients with Focal Cortical Dysplasia Type IIb and Tuberous Sclerosis Complex Is Correlated with 18F-FDG PET-CT Values.....48
Female mice lacking ERβ display excitatory/inhibitory synaptic imbalance to drive the pathogenesis of temporal lobe epilepsy.....50
Neural Synchronization of compromise in Third Party Punishment: A fNIRS Hyper-scanning Study..... 51
The development of computational mentalizing during social cooperation from childhood to adulthood.....54
Genes in immune pathways associated with abnormal white matter integrity in first-episode and treatment-naïve patients with schizophrenia..... 56
Impacts of aberrant social feedback processing on later memory, social evaluation, and social decision-making in depression..... 57
Compensation in the mirror neuron system for amygdala dysfunction in individuals with higher autistic traits..... 59
Numerosity representation in a deep convolutional neural network: from physical number to perceptual number.....61
面孔情绪与种族信息注意捕获的差异：来自行为和 ERP 的证据.....63
Modality-general and specific neural activities in conflict processing..... 65
To blame or not? Modulating third-party punishment with the framing effect.....67
Within-group synchronization in the prefrontal cortex associates with intergroup conflict.....69
Altered effective connectivity from the insula to the amygdala mediates the relationship between psychopathic traits and the Harm moral foundation..... 70
Functional magnetic resonance imaging of the interaction between central and peripheral processes in Chinese handwriting..... 72
Nostalgia modulates responses to death-related stimuli: A neurophysiological approach..... 73

Association of sleep quality with negative emotions by a combined voxel-based morphometry and resting-state functional connectivity study..... 74
EEG denoise Net: A benchmark dataset for deep learning solutions of EEG denoising76
Rest-task Modulation of fMRI-derived Global Signal Topography is Mediated by Transient Co-activation Patterns..... 78
Vertex Potentials Selectively Reflect Pain Discrimination..... 80
不愉悦气味对年轻男性警觉注意的影响:来自行为与 ERP 的证据.....82
EEG research on the performance of tracking multiple objects in ice-hockey athletes83
负面评价恐惧的认知神经机制：基于对社会评价效价和情境的加工.....85
Effects of Retrieval-Extinction Training on Internet Gaming Disorder.....87
Impaired Alpha Rhythm in Bad Sleeper during Nap: A High-density EEG Study.....88
ERPs reveal the time course of knowledge integration.....90
Emerged human-like performance of expression representation in a deep convolutional neural network.....92

Theta oscillations in prolactinomas: Neurocognitive deficits in executive controls

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Objective

Impairment of cognitive functions has been reported in prolactinomas. Specifically, substantial evidence has shown that pituitary patients suffer from deficits in attention, working memory, executive function, depression, and emotion processing. Amidst, working memory and attention control can be modulated by inhibitory control, which also reflects the capability of suppressing inappropriate actions. However, the electrophysiological mechanisms of response activation and response inhibition in prolactinomas remain unclear. Thus, in this study, we aimed to examine changes in the ERPs (N200 and P300 components) and oscillations (theta and alpha bands) in prolactinoma patients to reflect the impaired response activation and response inhibition.

Methods

21 prolactinoma patients and 21 healthy controls were recruited. Participants sat in the semi-dark test room with the screen 100cm away from the eyes. Double-triangle was applied as target stimuli (Go) and single-triangle was applied as nontarget stimuli (Nogo). These stimuli appeared on the central computer screen (physical luminance = 60 cd/m^2). In each trial, the stimulus lasted 50ms, followed by the interstimulus interval (750ms). Once the Go stimuli appeared on the screen, the participant should quickly press the button, but do not press the button when the Nogo stimuli appeared. There were three blocks in total, each of which contained 60 Go and 40 Nogo trials. Participants made a full practice before the formal EEG recording. During the whole process, participants needed to watch the screen center leisurely and reduce their eye blinks and body movements as possible as they could.

Results & Discussion

Compared to the healthy controls (HCs), the patients demonstrated worse performance and there were significant negative correlations between prolactin (PRL) levels and behavioral results. Meanwhile, patients' P300 amplitudes in the Go and Nogo conditions were smaller than the HCs. The amplitudes of N200d (difference between Go and Nogo stimuli) in patients were smaller than the HCs as well. Lower frontal theta power was found in the patients than the HCs in both Go and Nogo conditions, which indicated a deficit in response activation and inhibition. Moreover, the frontal theta power negatively correlated with PRL levels, which implied that PRL hypersecretion caused the dysfunction of response control by interfering frontal theta oscillations. Patients also showed lower parieto-occipital alpha power than the HCs, which suggested that the impaired response inhibition may arise from deficient

attention control.

Conclusions

This study revealed the neurocognitive discrepancies between prolactinomas and the HCs. The frontal theta oscillation was highlighted as the electrophysiological markers of the impaired response control in prolactinomas. The ERPs (N200, P300, and difference waves) and oscillation (theta and alpha) could be the potential biomarkers of executive and inhibitory dysfunction in prolactinomas, and the ERP-EEG technique may be used in clinical settings to quantitatively measure the cognitive function considering its low cost, high temporal resolution, and efficiency.

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Mapping Between Scalp Low-frequency EEG Rhythms and Current Source in Deep Brain

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Objective

Local field potential(LFP) power is derived from the scalp EEG, whose significant value can reflect the strength of neural signal in the deep brain, thus it has been widely utilized in the analysis of EEG rhythms in the neural system. However, the electrical significance of power hasn't been understood totally to affect the accurate detection on EEG rhythms. Therefore, the sensitivity of low-frequency power was studied by the forward problem based on the theory of equivalent dipole current in a generalized expression of EEG.

Methods

The oscillatory field potentials(FPs) evoked by a low-frequency dipole current were estimated by finite element method(FEM) on the surface of a homogeneous one-layer head model, where the power values were estimated by Hilbert transform and indicated by the FPs at the amplitude of dipole current, and the significant power values were concerned.

Results & Discussion

It was found that low-frequency LFP SPs were sensitive to multiple factors, such as, brain tissue anisotropy, position of dipole current, and sites of recording electrodes on the head surface. The effect of anisotropic conductivity of brain tissue on LFP SP could be reversed by the moment orientation of dipole current, implying that the direction of rhythmic generator could be the determinant factor to the influence of anisotropy on the low-frequency power of EEG rhythms on the scalp.

Conclusions

The work mapped the relationship between the scalp EEG and the electrical activity in the deep brain, in particular, highlighted the important role of orientation of source current in the mapping. Therefore, it might be helpful to the measurement and analysis of spontaneous low-frequency EEG rhythms.

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Altered resting-state functional connectivity within medication-naïve children with attention deficit hyperactivity disorder

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Objective

The latest researches of ADHD have gradually more focused on both the cool and hot executive functions. However, the results of the investigation using functional brain imaging in this area still remains a vast amount of uncertainty. Hence, we use resting-state functional connectivity analyses to explore the whole brain functional connectivity patterns based on the seed regions to get a deeper understanding of the neurophysiological mechanism of cool and hot executive functions in ADHD.

Methods

30 drug-naïve children with ADHD selected from a hospital and 33 age-matched healthy children from the local school nearby were included in this study. The seed region of interest (ROI) in the current study approximates the location of the bilateral amygdala, orbital frontal cortex and ventral striatum that were extracted from the Harvard Oxford anatomical labeling template from DPABI software. Whole-brain seed-based functional connectivity analyses were conducted using the three ROIs. Next, within-group and between-group connectivity patterns showing positively as well as negatively correlated networks of the three ROIs were demonstrated and compared. At last, to investigate the functional connectivity of the three ROIs, exploratory correlation analyses were performed between each cluster and the age, attention-deficit scores, hyperactivity scores of each group.

Results & Discussion

The functional connectivity patterns of the three ROIs in the whole brain were very similar in the right and left hemispheres within the two groups. Compared with the normal controls, the amygdala in children with ADHD showed decreased functional connectivity with the right cerebellum, while increased functional connectivity with the left putamen and right anterior cingulate cortex. Significant increases in intrinsic activity between the orbital frontal cortex and the left anterior cingulate cortex were also observed in ADHD children compared to the normal controls. At the same time, the right inferior frontal gyrus also showed a significant between-group difference in functional connectivity with the ventral striatum. These aberrant connectivity implied deficits in both cool and hot executive functions, especially the emotion dysregulation showed in ADHD children. The age and strength of functional connectivity of the right cingulate gyrus to the amygdala showed a significant positive correlation in ADHD children, but not in NC, which suggests maturation delay in ADHD. No other significant correlation between age, attention-deficit scores, hyperactivity scores and connectivity strength was found.

Conclusions

Significantly altered resting-state functional connectivity found in our present study comparing between ADHD children and healthy control implied the deficits in

executive control and emotion processing within ADHD patients, which provides more perspectives in treating the symptoms regarding of emotional problems in ADHD.

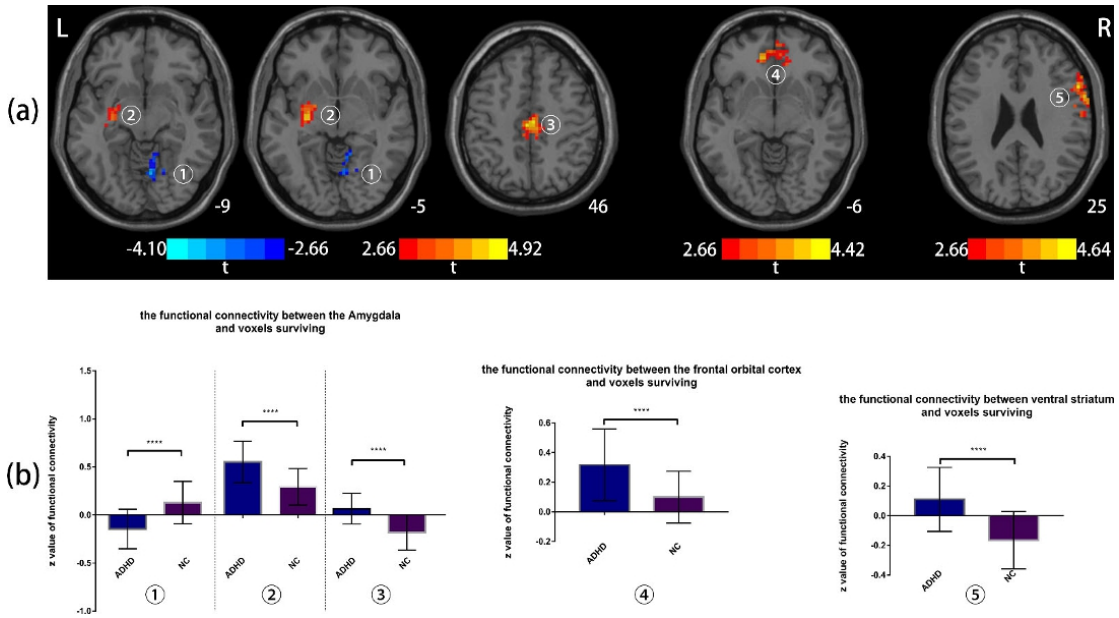


Figure 1. Results of two-sample t-tests on the functional connectivity of the amygdala, orbital frontal cortex and ventral striatum (a) Yellow color indicates increased functional connectivity with the amygdala (①-③), orbital frontal cortex (④) and ventral striatum (⑤) in the ADHD group and vice versa for the blue color. (b)The functional connectivity between the amygdala (①-③), orbital frontal cortex (④), ventral striatum (⑤) and voxels surviving, they had significant differences.

Aberrant reward dynamics in depression with anticipatory anhedonia

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Objective

Previous studies have shown that anticipatory anhedonia is linked to abnormal reward processing. However, whether the abnormal reward processing was due to depression symptom or anticipatory anhedonia was not clear. Further, few studies have divided depressed individuals by anticipatory anhedonia with matched depression symptoms and better understand the effect of anticipatory anhedonia on reward processing. To fill the vacancy, we aimed to explore the relationship between reward dynamics and anticipatory anhedonia in depression and healthy controls.

Methods

Twenty-four depressed participants were enrolled in the HAA group (high anticipatory anhedonia group), with the remainder twenty-five enrolled in the LAA group (low anticipatory group), and twenty-nine healthy controls (HC). All participants completed the Money Incentive Task, in which participants were first presented with a 250 ms cue, which was followed by crosshair fixation that was lasted for 2000–2500 ms. Then, a target square was presented for 160–260ms. Participants were required to respond to the target as fast as possible by pressing the 'space' key. Feedback signals following the disappearance of the target were provided according to the responses of the target and lasted for 1450 ms. The whole paradigm consisted of two kinds of trials including incentive and neutral unreinforced trials. In the incentive trials, the cue that signaled the potential reward (1.5 yuan or 3 yuan) was denoted by a horizontal line in a circle in the low reward condition and a circle with two horizontal lines in the high reward condition. The feedback signals were a cartoon smiling face or a crying face and the current total amount of money was provided below the faces. No matter the success or failure response, there was no reward in neutral unreinforced trials in which the cue was a triangle and the feedback signal was a line.

Results & Discussion

We found a significant interaction effect in feedback-related negativity (FRN), which showed a smaller amplitude for reward cues compared with neutral cues in HCs and LAA patients. However, no reward-related effect was found in HAA patients. In addition, we found that a significant relationship between FRN, fb-P3 and cue-N1, cue-N2 was displayed in HCs, while a significant relationship between FRN, fb-P3 and cue-P2 was displayed in the HCs and LAA patients. However, no significant relationship was found in HAA patients. Our results suggest that the link between the anticipatory and consummatory phases was interrupted, which may drive by aberrant consummatory reward processing for high anticipatory anhedonia.

Conclusions

In summary, relative to the HC and LAA groups patients in the HAA group showed aberrant consummatory reward processing for unsignificant reward-related effect as inferred by FRN. Besides, the relationship between ERPs elicited by anticipatory

and consummatory stimuli did not reach significance in the HAA group, although the relationship was preserved in both the LAA and HC groups. Our results suggest that the link between anticipatory and consummatory phases was interrupted, which may cause by consummatory reward processing in HAA.

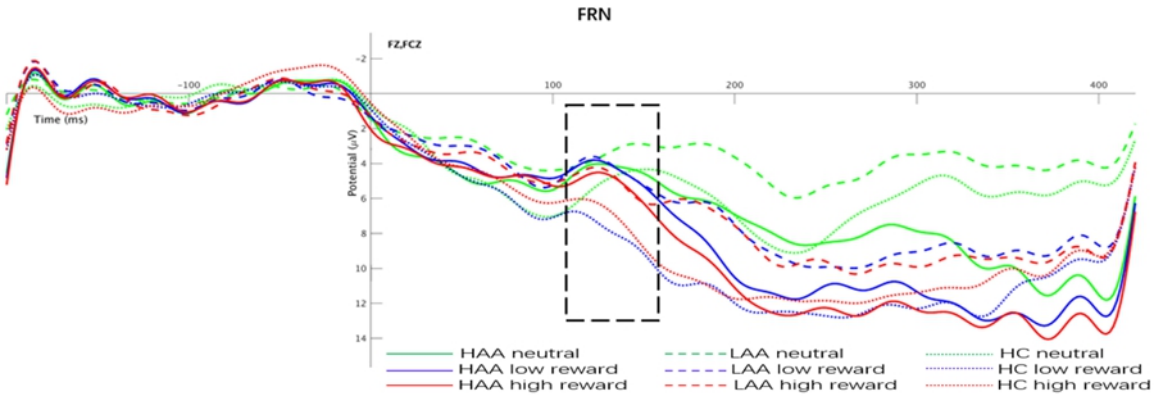
Acknowledgement:
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Correlations between ERPs during anticipatory phase and consummatory phase.

	HC		LAA		HAA	
	FRN	fb-P3	FRN	fb-P3	FRN	fb-P3
Cue-N1	0.41*	-0.50**	0.08	-0.01	0.24	0.17
Cue-N2	0.42*	-0.41*	0.24	0.10	0.17	-0.22
Cue-P2	0.34*	0.54**	0.42*	0.42*	-0.08	0.03
Cue-P3	0.14	-0.10	0.25	0.32	0.14	-0.11

Note: HC, healthy control; LAA, low anticipatory anhedonia group; HAA, high anticipatory anhedonia group. *p< .05, **p< .01.

Figure. Amplitude of REPs during the anticipation phase and consummatory phase, where the dotted box demarcate the time window during which the FRN (110, 160ms) were scored. HC, healthy control; LAA, low anticipatory anhedonia group; HAA, high anticipatory anhedonia group. Neutral, a trial without reward cue or reward feedback; Low reward, a trial with low reward cue or 1.5 yuan reward feedback; High reward, a trial with high reward cue or 3.0 yuan reward feedback;



Emotion recognition based on TQWT-BGWO and EEG

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Objective

As an important part of affective computing, emotional brain-computer interface based on EEG signals is a hot topic in the field of human-computer interaction, and it is also a combination of psychology, artificial intelligence and computer.In this study, the pre-processed EEG signals were decomposed by the tunable Q-factor wavelet transform (TQWT), and the five subbands with the highest energy ratio were selected.Secondly, the sample entropy, Hjorth parameters, normalized second-order difference mean and second-order difference mean of each subband were extracted as features, and the feature matrix was optimized by BGWO.Finally, SVM is used for classifier training.An algorithm was proposed to classify the arousal and pleasure of 32 participants in the DEAP dataset into five categories. The maximum recognition accuracy was 88.1% and the average minimum classification error (MCE) was 37.89% after 6 fold cross-validation.

Methods

The Database for Emotion Analysis Using Physiological Signals (DEAP) was used in this study.In this study, 32 EEG signals from the preprocessed version of the dataset were analyzed and processed using two dimensions of valence-arousal.In this version, the data was sampled down to 128Hz, and EOG artifacts were removed. The signal was filtered to 4-45Hz through a bandpass filter, and the data was averaged as a general reference.The threshold value of 3 was set to divide the degree of pleasure and Arousal into three levels respectively. 1-3, 4-6, 7-9 were mapped to "-1", "0", and "1" respectively, and five types of emotion were identified on two dimensions.

Results & Discussion

The average accuracy and the maximum accuracy were improved by 10.47% and 1.51% by the two-value grey Wolf optimization.The maximum identification accuracy of the algorithm in this paper is 88.10%, and the average identification accuracy is 62.91%.The average accuracy exceeded the natural probability by 37.91%.From the classification accuracy of the five types of features in the table, the average classification accuracy of the four time-domain features is all higher than that of the sample entropy features, indicating that the time-domain features are better than the frequency domain features in resolving emotions.

Conclusions

The experimental results show that the average accuracy of this method is 62.91% and the average minimum classification error is 37.89% for the five kinds of emotions.This method provides a new idea for online emotional brain-computer interface based on EEG signals.

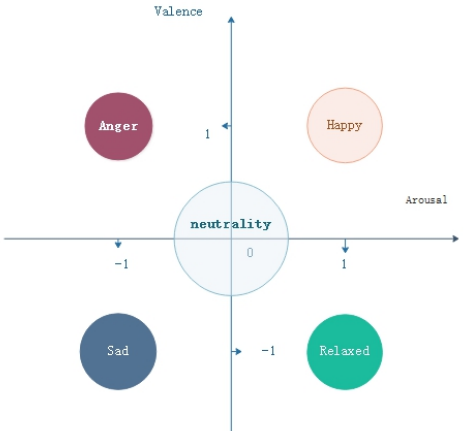


Figure 1. Schematic diagram of five types of emotions in valence-arousal

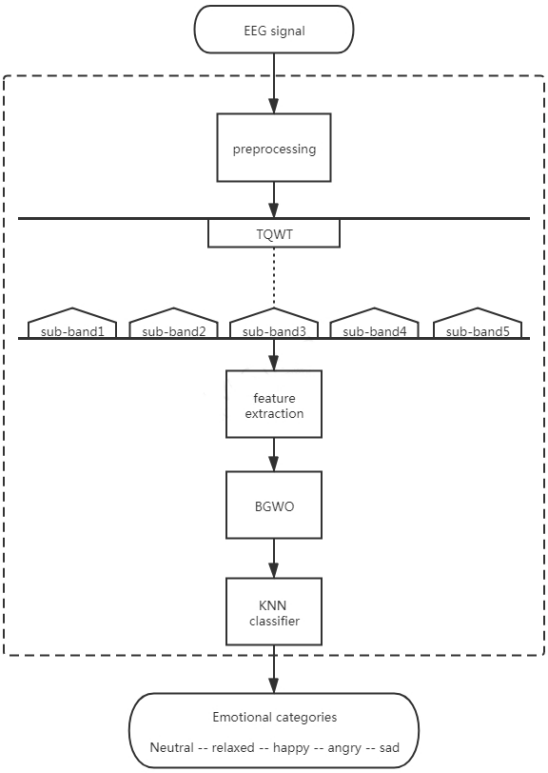


Figure 2. Flow chart of this research method

共情关怀对公平决策的影响——来自 ERP 的证据

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目的

在决策过程中人们不仅关注公平，也关心他人福祉。本研究旨在探讨当个体遵循的公平准则与指向他人的共情相冲突时，人们会如何处理二者之间的关系。已有大量研究探讨了共情对利他决策的影响，但重点关注了特质共情的作用而较少考虑状态共情对公平决策的影响。本研究采用事件相关电位技术(event-related potential, ERP)来评估状态共情对公平决策的影响。

方法

37 名健康大学生完成了多轮单次最后通牒博弈(ultimatum game, UG)任务。我们采用 Biosemi 32 导联脑电设备记录其脑电活动。通过操纵 UG 任务中提议者的身份来诱发被试的状态共情：高共情条件下提议者身份为留守儿童，低共情条件下提议者身份为普通儿童。被试作为响应者对每一个提议者提出的分配方案进行决策，若选择接受则双方得到相应的收益，若拒绝则双方收益均为 0。其中分配方案根据其公平性可分为公平分配、劣势不公平分配和优势不公平分配三类。

结果与讨论

行为结果发现劣势不公平条件下，高共情条件的接受率高于低共情条件，而优势不公平条件下呈现相反的结果；脑电结果显示：(1)低共情条件下，他人提出的优势不公平提议较高共情条件诱发了更负的 AN1，而劣势不公平和公平条件下二者无显著差异；(2)优势不公平条件下，高共情条件诱发的 P2 波幅显著大于低共情条件，而优势不公平条件下，低共情条件的 P2 波幅略大于高共情条件；(3)高共情条件下，他人提出的劣势不公平提议诱发了更负的 MFN，而低共情条件下三者差异不显著；(4)P300 在公平条件下的波幅更大，并未受到共情关怀的调节。结果表明共情能够调节公平决策行为以及公平加工的早期注意、动机等认知过程与情绪体验，但不影响公平加工的后期阶段。

结论

当共情与公平准则相冲突时，个体会优先依赖共情指导行为；同时共情主要调节了公平加工的早期阶段，而由 P300 所表征的高级认知过程仅受到公平性的影响，不受共情的调节。本研究发现共情能够调节人们的公平决策行为以及早期认知过程和情绪体验，这对于解释特定情境下人们的公平决策行为提供了新的思路，同时提示我们可以通过操纵共情水平来调节人们的公平行为。

Social value orientation modulates fairness processing during social decision-making: evidence from behavior and brain potentials

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Objective

In highly complex social environments, people must consider the outcomes of their own behaviors along with others' during social interactions; such considerations influence the decision-making process. Fairness norm plays crucial roles in social decision-making. Social value orientation (SVO) characterizes stable individual differences by an inherent sense of fairness in outcome allocations. Using the event-related potential (ERP), this study investigated differences in fairness decision-making behavior and neural bases between individuals with prosocial and proself orientations using the Ultimatum Game (UG).

Methods

Sixty young, healthy participants were recruited from the university population. After measuring SVOs, 30 proselfs and 29 prosocials played the UG in the responder role, while EEGs were recorded. In this crucial session, participants were informed they would receive 300 monetary offers proposed by volunteers and previous participants from the database, but they would receive only one offer from a particular proposer. The entire task consisted of 300 trials in which all stimuli were displayed in the center of the computer screen. Each trial began with a fixation cross appearing for 500ms followed by a picture of a 10-yuan bill (2.6◦ × 1.3◦) for 500 ms against a black background. A fixation cross was then presented again for 800 to 1200ms. Later, the offer screen was presented for 1000ms, depicting a distributive outcome of 10 yuan between the respective proposer and the participant (responder). Participants decided to accept or reject the offer at this point by pressing either the F or J key with their left or right index finger. After an interval of 800–1200 ms, feedback on the offer was presented for 1000 ms. Trials were separated by an inter-trial interval of 500 ms.

Results & Discussion

As expected, the results demonstrated that individuals with distinct SVOs responded differently to fairness in the UG and revealed the neural underpinnings of SVO modulation of fairness processing. Prosocials appeared more satisfied with fair offers and more upset about being treated unfairly than proselfs, in which case prosocials were less likely than proselfs to accept unfair offers. Electrophysiologically, three ERP indicators (the P2, MFN and P3), revealed group differences in fairness processing. Compared with proselfs, prosocials exhibited automatic processing to the fairness factor as evidenced by a significant difference in the P2 for fair and unfair offers. Furthermore, prosocials exhibited deeper processing to fairness in later time windows, reflected in the MFN and P3. Moreover, the fairness effect on the MFN (d-MFN) mediated the relationship between individuals' SVOs and behavioral responses to unfairness in the UG.

Conclusions

This study unveiled a modulating effect of SVO on individuals' fairness processing during social decisionmaking using an ERP technique. Behaviorally, prosocials were more willing to reject unfair offers than proselfs. Electrophysiologically, relative to proselfs, prosocials exhibited automatic intuitive processing of fairness at an early stage represented by the P2. In the middle processing stage, unfairness greatly violated prosocials' expectations and triggered stronger negative emotional reactions than in proselfs as depicted by the MFN. Compared with proselfs, fair outcomes met prosocials' decision-making motivation and attracted more of their attention as indicated by the P3. These findings shed light on differences in the behavioral patterns and temporal characteristics of neural activities among individuals with distinct SVOs in fairness processing.

Acknowledgement: This work was supported by grants from the National Natural Science Foundation of China (31970986, 31771206), the Major Project of National Social Science Foundation (19ZDA363).

个体内高度的静息态变异性与更好的认知控制有关:来自 STROOP 任务的证据

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目标

皮层噪声通常被认为可能会损害认知功能，但最近的发现表明，一些认知过程实际上可能会从噪声更大的大脑中受益。鉴于认知控制能力与通过脑电图和功能磁共振成像(fMRI)评估的静息态活动特征相关，我们将静息态 fMRI 的个体内变异性和冲突诱导 Stroop 任务中的个体间变异性联系起来，假设静息态活动中个体变异性(IIV)程度越高，在 Stroop 任务中 IIV 程度越低。即静息态活动中的 IIV 与 Stroop 任务中的 IIV 之间呈负相关。

方法

被试来自西南大学的 SLIM 数据库，共 39 人。Stroop 任务使用了三组刺激：一致、不一致和中性刺激。实验中使用了红、绿、蓝、黄四种颜色。所有被试用左手食指回应红色的单词，用左手中指回应绿色的单词，用右手食指回应蓝色的单词，用右手中指回应黄色的单词。每种刺激由 24 次试验组成，且所有试验都是随机呈现的。所有结构和静息态功能磁共振图像均使用 3T 西门子(德国埃尔兰根)Trio MRI 系统扫描仪获得。

结果

平均而言，被试在不一致试验(M = 2.39, SD = 3.00)中的错误明显多于中性试验(M = 0.97, SD = 1.94; t(38) = 4.81, p < 0.001)和一致试验(M = 1.15, SD = 2.08; t(38) = 3.45, p = 0.001)中的错误。反应时间(RT)在不一致试验(M = 952.23, SD = 358.87)中比在中性试验(M = 855.96, SD = 291.49; t(38) =4.10, p < 0.001)和一致试验(M = 809.55, SD = 251.96; t(38) = 5.09, p < 0.001)中更显著。SDs(IIV 测量)显示不一致试验(MIIV = 376.72, SDIIV = 288.52)和中性试验(MIIV= 309.03, SDIIV = 237.22; t(38) = 2.60, p = 0.013)之间的差异显著，而不一致和一致试验(MIIV = 329.15, SDIIV = 262.05)之间的差异并不显著(t(38) = 1.33, p = 0.191)。在所有条件下，平均 RT 与 SD 呈正相关，表明更高的 RT 与更高的 IIV 有关。

结论

静息态 fMRI 中的 IIV 与 Stroop 任务中的行为表现有关，较高的静息态 IIV 与不一致试验和中性试验中较小的 RT 波动以及所有试验中较快的 RT 有关。这种模式表明，较高的静息态 IIV 伴随着更有效的冲突监测。

经颅直流电刺激左侧初级运动皮层对言语智力的影响

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目的

已有的脑成像研究显示，个体在青少年期的言语智力(verbal intelligence quotient, vIQ)发展和其左侧初级运动皮层(primary motor cortex)的灰质密度增加有关，而这一区域的结构性变化和个体的操作智力变化无关。基于前人研究结果，本研究使用经颅直流电刺激(transcranial direct current stimulation, tDCS)，探究了作用于左侧初级运动皮层的不同极性刺激对个体言语智力成绩的影响，就该区域在个体言语智力表现上的因果性作用进行检验。

方法

本研究招募北京某高校大学生被试 61 名，采用被试间设计，将其随机分为阳极刺激组(20 人)、阴极刺激组(20 人)和假刺激组(21 人)。使用韦氏成人智力量表中国版(WAIS-RC)中言语智力分量表中的领悟、相似性两项分测验，以及操作智力分量表中的数字符号、木块图两项分测验，将原测验题目分为难度相当的两份实验材料，分别用于各组被试接受刺激前后的智力测量，对被试接触两份实验材料的顺序进行平衡。

结果和讨论

进行 3(tDCS 刺激条件：阳极刺激，阴极刺激，假刺激)× 2(前后测：tDCS 刺激前，tDCS 刺激后)的重复测量方差分析，以对不同刺激组被试的测验得分变化进行检验。结果显示：(1)言语智力方面(包括领悟和相似性分测验)：各分测验中刺激条件和前后测的交互作用显著，阳极刺激组后测得分显著提高，假刺激组前后测得分无显著差异，而阴极刺激组在后测中得分显著下降。(2)操作智力方面：数字符号分测验中，刺激条件和前后测的交互作用不显著，前后测的主效应显著，各个刺激分组均在后测中表现出了成绩的显著提高，提示可能出现了练习效应；木块图分测验中，刺激条件和前后测的交互作用不显著，各个刺激分组在前后测中的得分无显著差异。上述结果表明，施加于左侧初级运动皮层的刺激对个体在言语智力任务中的表现有着重要影响，而不会改变个体在操作智力任务中的表现。

结论

本研究使用 tDCS 技术对左侧初级运动皮层与言语智力和操作智力之间的关系进行了探讨。揭示出这一区域的兴奋性水平对言语智力的独特影响，同时为如何在较短时间内使用安全有效的方法促进个体的智力表现提供了一定的启示。

The semantic priming of emotional concept on bodily expressions

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Objective

Body expression can accurately express emotions such as pride, shame, fear and disgust. Recent research has carried out study on the influencing factors of body expression processing. However, it is not clear how semantic concepts affect the processing of body expression in social situation and the effect of semantic concepts on body expression in different emotion. Here, we use event-related potentials to explore the effect of emotional vocabulary on body expression and its electrophysiological basis.

Methods

Experiment 1 and experiment 2 recruited 25 and 31 right-handed participants respectively. The body pictures (30 angry,30 happy,30 neutral) were selected from the public face-body material library. Emotion concept words and emotion verbs are selected from the open Chinese emotional lexicon (10 happy, 10 angry,10neutral). The study used emotional semantic priming paradigm. In experiment 1, emotion concept words were presented as priming stimulus, and then the body expression pictures consistent or inconsistent with the emotional categories of the concept words were presented. Participants were asked to identify the category of the body image. The purpose of the experiment 2 is whether there are differences in recognition of body expressions under the priming of different types of emotional verbs.

Results & Discussion

Experiment 1 showed that happy concept words have a significant priming effect on the recognition of body expressions: under the initiation of happy concept words, the ACC of recognition of happy body expression is higher than neutral; the RT is faster than anger while recognizing angry body expressions, the RT of anger is faster than neutral. And ERP results showed that when recognizing happy body expressions, the amplitude of P300 elicited by angry concept words is more positive than neutral and happy words, which means that priming effect is stable and support the negative bias of emotion. Behavioral results of experiment 2 showed that ACC of angry verb priming was lower than happy and neutral when recognizing happy body expressions. When recognizing angry body expressions, the ACC of anger verb priming condition is higher than happy and neutral, and the RT is faster than happy and neutral. The ERP results showed that when recognizing happy body expressions, the amplitude of P300 elicited by happy concept words is more positive than neutral and angry words, suggesting that emotional verbs are more closely related to physical actions than emotion concept words and also supporting the updating theory.

Conclusions

Emotional concept words promote the recognition of body expressions within categories; angry verbs promote the recognition of angry body expression and hinder the recognition of happy body expression; the effects of emotional words on body

expression recognition are different in time. Emotional concept words provide category information for body expression recognition, and emotional verbs provide emotional background. The integration of happy semantics and body expressions occurs in the P300, and the integration of anger semantics and body expression occurs in the N400.

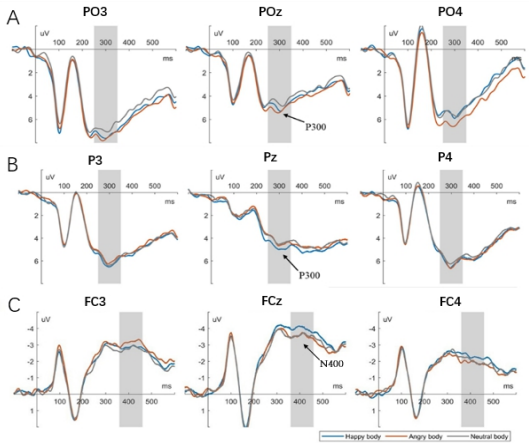


Figure 1 (A)P300 amplitude of different emotional primes when identifying happy body expression in experiment 1. (B) P300 amplitude of different emotional primes when identifying happy body expression in experiment 2. (C) N400 of different emotional primes when identifying angry body expression in experiment 2.

Research on the Stroke Risk Prediction Based on the Fused Feature of EEG Data

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Objective

As a non-invasive technique, electroencephalographic (EEG) can be used to analyze the brain electrical activity for the understanding and diagnosis of neurological diseases, such as stroke. Studies have shown that EEG data is a non-stationary time series with complex nonlinear dynamics characteristics. Complexity can be used to measure regularity of EEG data based on nonlinear time series analysis. In this paper, Multifractal Detrended Fluctuation Analysis (MF-DFA) is employed to extract the features of stroke patients' EEG data on multifractal complexity theory. The ensemble method based on extreme learning machine is used to construct the model for prediction the risk of stroke.

Methods

The EEG data of 195 cases of cerebral infarction patients and 171 cases of cerebral hemorrhage patients were collected from the Department of Neurology of Shanxi Provincial People's Hospital. All EEG data are in 8 leads, and the leads are: Fp1, Fp2, T3, T4, C3, C4, O1, and O2. MF-DFA complexity theory is utilized to extract four kinds features of stroke EEG data for predicting the stroke. The extracted four kinds features are listed as follows: the generalized Hurst exponent hq_{max}, the multifractal features α_{max} and α_0, the scale index τq_{min}. The following three scenarios were designed to evaluate the performance of the proposed feature extraction methods: (1) Extract each kind feature from all stroke EEG data for comparing the performance differences of above four kind features. (1) Extract the above four features from each lead of stroke EEG data for comparing the performance differences of 8 leads. (3) To get the fused features by combining the features together, which have the best performance in scenarios (1) and (2). The ensemble method based on extreme learning machine is used for getting the stroke risk predicting model.

Results & Discussion

The stroke risk prediction performance is evaluated by accuracy criterion. The experimental results indicated that: (1) Among all four kind features, the feature of generalized Hurst exponent hq_{max} had the best stroke risk prediction performance, with accuracy of 96.54%. (2) Among the EEG data of all 8 leads, the above four kinds features from lead C4 possessed the best prediction result, with accuracy of 97.63%. (3) The fused feature of lead C4 and hq_{max} gave the best prediction performance in all scenarios with accuracy of 98.05%.

Conclusions

The performance based on the fused features of the four kinds features of lead C4 and the Hurst exponent was the best, indicating that the efficiency of the proposed

MF-DFA method in predicting the risk of stroke .

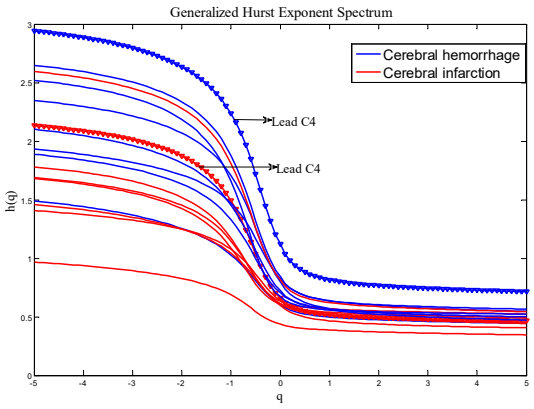


Figure1 Generalized Hurst exponent spectrum of stroke EEG data

A Human-Autonomous Vehicle Interaction Platform Based on Apollo-LGSVL Co-simulation System with EEG Acquisition

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Objective

Autonomous vehicles (AVs) and related technologies have become rather mature in recent years, and the interaction between human drivers and AVs on the road has also become a reality. However, there is a lack of research on the dynamic interaction between them. The main reasons include the lack of interactive driving platforms as well as the insufficient data acquired from human-vehicle interactions, especially human-AV ones, which makes it difficult to reflect the power of data-driven deep learning models. Therefore, we build up such a platform here, based on an Apollo-LGSVL co-simulation system, to allow multimodal driving data collecting including EEG signals.

Methods

The LGSVL (LG Electronics) and Apollo (ApolloAuto, Baidu) systems are used for setting up a virtual interaction environment and for controlling AVs accordingly (Figure 1). After the recruited volunteers have completed a series of EEG signal baseline calibration (Figure 2), they will complete tasks (e.g., lane changing and overtaking) of interacting with the AV with a set of steering wheels (Logitech G29) on a series of types of virtual roads (e.g., roundabouts and crossroads) designed by us (Figure 3). During this process, the volunteer's EEG signals from the visual and motor cortices are recorded. At the same time, the driving data of the vehicle controlled by human and the AV are recorded, including speed, acceleration, steering wheel angle, etc.

Results & Discussion

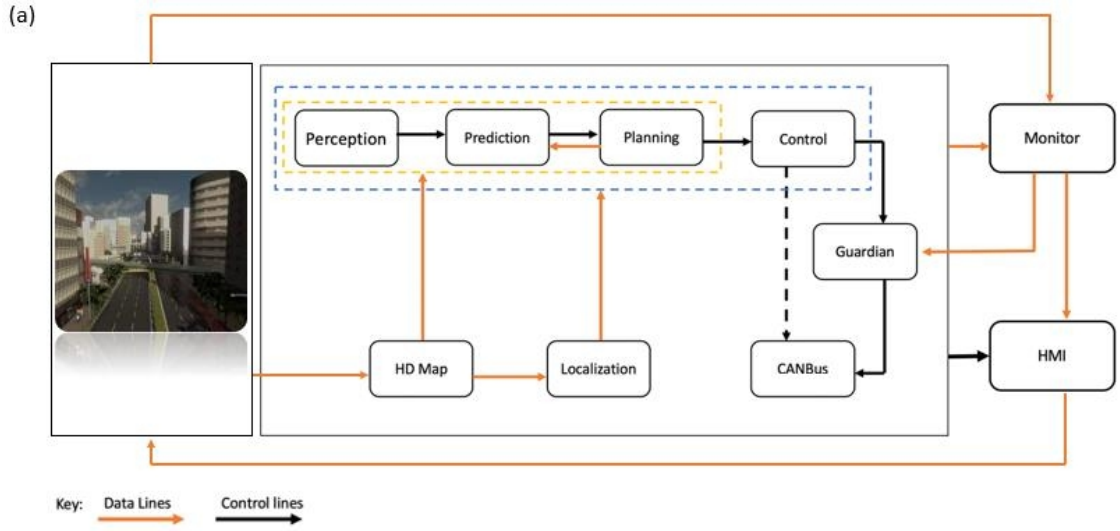
By designing different maps and tasks on such a platform, the driving behavior data of human drivers and AVs can be widely collected, which allows further study on the mental activities and driving strategies of human drivers in the process of human-autonomous vehicle interaction. At the same time, we can utilize the inverse reinforcement learning model to fit the multimodal behavioral data during the interaction, which can provide reward functions of human drivers in different interaction scenarios. Furthermore, through such interactive functions with different weights, we can analyze the acceptance of AVs by human drivers and the differences in their decision-making under different risk factors.

Conclusions

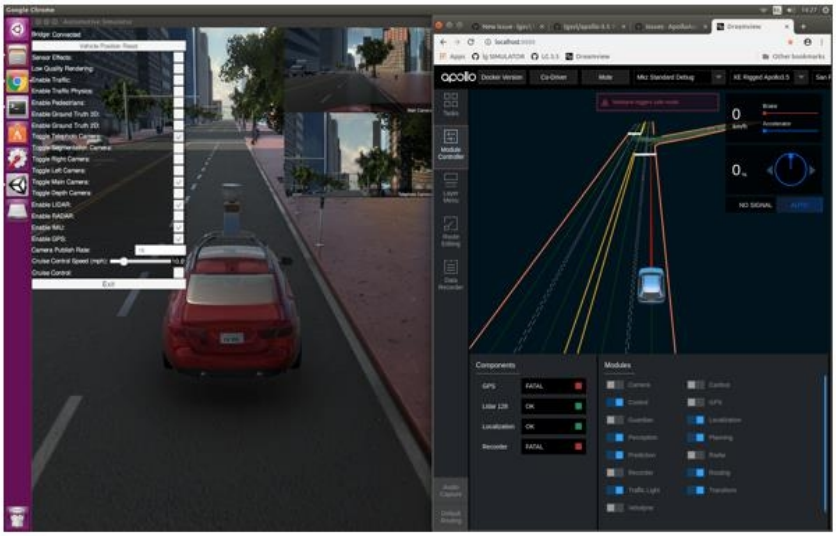
Our study provides a human-AV interaction platform that allows loading various task-driving maps for collecting human EEG signals as well as human/AV driving behavior data. This platform is complete, easy to use and has research and practical value.

Figures

Figure 1. (a) The general workflow of our Apollo-LGSVL co-simulation system, in which the left part



(b)



represents the virtual driving environment generated by LGSVL where human driver interacts with AVs, and the right part is the workflow of how Apollo controls an AV. (b) The real-time working screen of the co-simulation system (Left: LGSVL Simulator; Right: Apollo DreamView).

The hierarchical sensitivity to social misalignment during decision-making under uncertainty

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Objective

Social misalignment occurs when a person's attitudes and opinions deviate from those of others. Most previous studies used a binary categorization for individual responses in social interaction: agreeing or disagreeing with the majority. This dichotomy may be too simple to unravel the complex dynamics of social misalignment. Our study employed event-related potentials (ERPs) to assess the influence of different levels of social misalignment on neural activation and its temporal characteristics of the cognitive processes during decision-making under uncertainty.

Methods

Thirty-four healthy participants were recruited from several universities in Beijing, China. During each trial, participants played a forced-choice gamble, and they observed the decisions of four other players after they made a tentative decision, followed by an opportunity to keep or change their initial decision. Behavioral and event-related potential data were collected.

Results & Discussion

Behaviorally, the stronger the participants' initial preference, the less likely they were to switch their decisions, whereas the more their decisions were misaligned with the majority, the more likely they were to switch. Electrophysiological results showed a hierarchical processing pattern of social misalignment. Misalignment was first detected binarily (i.e. match/mismatch) at an early stage, as indexed by the N1 component. During the second stage, participants became sensitive to low levels of misalignment, which were indexed by the feedback-related negativity. The degree of social misalignment was then processed in greater detail, as indexed by the P3 component. Moreover, such hierarchical neural sensitivity is generalizable across different decision contexts (i.e. risky and ambiguous).

Conclusions

Our findings demonstrate the hierarchical sensitivity to social misalignment, and such a neural processing pattern can be generalized from risky to ambiguous decision-making. Our study facilitates a better understanding of the neural underpinnings of social misalignment during decision making under uncertainty.

Acknowledgement: This work was funded by the National Natural Science Foundation of China (31920103009, 32071083, 31671173 and 32020103008).

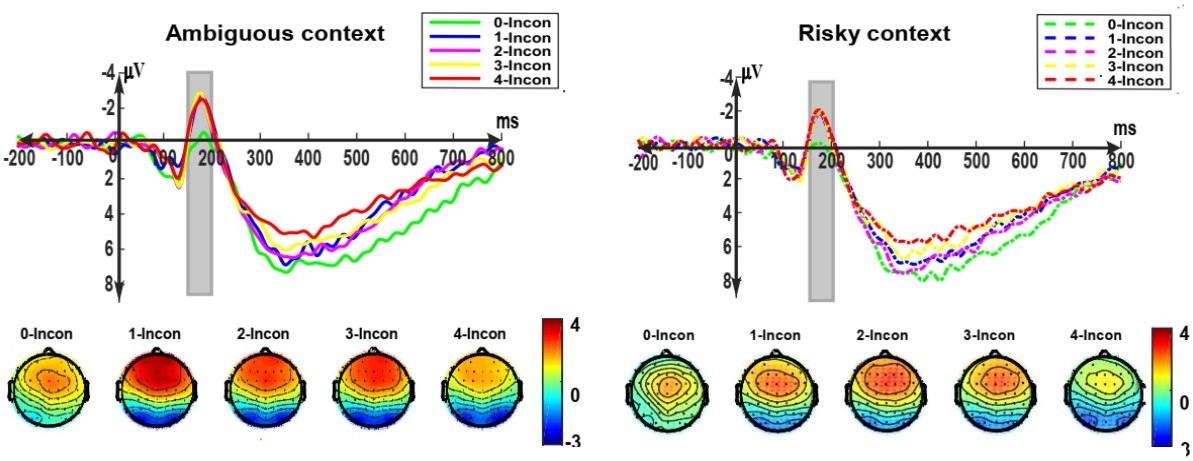


Fig. 3. Grand average ERP of the N1 component in ambiguous and risky contexts. The waveforms represent the mean values of the data at the electrode sites PO3, PO4, PO5, PO6, O1 and O2.

Robust and reliable implicit categorization of food information and its healthfulness but not tastiness at the individual level through EEG frequency tagging

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Objective

Understanding the characteristics and mechanisms of food information processing is crucial for our understanding of obesity and disordered eating, with practical implications for interventions and policy making. Yet, despite decades of research, a reliable measure of food information processing remains elusive, making it a methodological bottleneck in obesity and disordered eating research. Furthermore, how fundamental attributes of food—tastiness and healthfulness—are processed remains largely unknown.

Methods

We first developed a culturally appropriate set of food stimuli (492) and nonfood stimuli (386). For nonfood images, we selected 288 images out of the 386 original nonfood images that were rated as highest in familiarity, with four sets of 72 picture each (animals, architecture, flowers, and tools). For food images, we selected 196 savory food pictures and added 134 savory food pictures, for a total of 330 pictures. Thirty two participants then individually rated the healthfulness and tastiness of the food pictures and the familiarity of both all pictures using a 6-point Likert scale. For each individual, we excluded 48 pictures that were rated as medium healthfulness and tastiness for that individual, resulting in 288 pictures in four sets of 72 food pictures each (i.e., crossing of healthfulness and tastiness).

One day after the picture rating session, each participant took part in an EEG session where randomly selected nonfood images appeared sequentially for 16.7 ms each (i.e., 6 HZ) for a total duration of 60 s, with the image contrast sinusoidally modulated. Importantly, every 5th image (i.e., 1.2 Hz) was a food image from one of four categories (crossing of healthfulness and tastiness), serving as the oddball. To control for low-level image properties—such as luminance, contrast, and color—we used diffeomorphic transformation (Stojanoski & Cusack, 2014) that scrambled the original images to create the corresponding control stimuli for food and nonfood images. Superimposed on the center was a series of letters. The task was either a low perceptual load task, to monitor the letter color, or a high perceptual load task, to monitor both the color and identity of the letter. Within each 60-s sequence, targets appeared for 4 times, each for 200 ms. To evaluate test-retest reliability, of the original 32 participants, 21 took part in a second EEG session at least 3 weeks apart, and 13 of them also took part in a third EEG session at least 6 weeks apart.

Results & Discussion

Signal-to-noise ratio (SNR) was calculated at each frequency as the ratio of the

amplitude at that frequency to the mean amplitude of the surrounding 20 frequencies. We found that 1) the SNR of food oddballs was much higher than that of control stimuli; 2) the effect was not modulated by perceptual load or food tastiness, but was higher for low healthfulness pictures and high healthfulness pictures; 3) the effect manifested at the individual level for all 32 participants, with greater SNR for the grand-averaged food oddballs than the control stimuli; 4) the effect was highly reliable, with Cronbach's alpha averaging 0.78, intraclass correlation (ICC) averaging 0.8 for the three sessions, and measurement error averaging 0.13 for the three sessions.

Conclusion

Using EEG frequency tagging, we demonstrated robust and reliable implicit categorization of food information at the individual level, with the effect modulated by healthfulness but not tastiness.

人类社会沟通系统的产生及其脑-脑机制的研究

刘洁琼，张如倩，李先春*

研究目标

人类社会沟通是人与人之间、人与群体之间思想与感情的传递和反馈的过程，以求思想达成一致和感情的共鸣。良好的社会沟通对促进人类健康、人际关系维持以及社会稳定具有重要的作用，而社会沟通缺陷已成为自闭症和精神分裂症患者的一个典型特征。揭示社会沟通系统的产生过程的影响因素及神经机制具有重要的理论和实践意义。本研究基于社会协作理论，采用“符号匹配”研究范式，运用基于近红外成像的超扫描技术，探讨社会沟通系统产生过程中的影响因素及脑间活动同步性的变化规律。

研究方法

共招募大学在读本科生 88 名，随机分组共形成 44 对同性别被试组。44 组被试需要分两次分别完成实验任务和对照任务。实验任务包含协调期（27 个试次）和测验期（18 个试次），两名被试通过互动、协调形成图形和字符间的匹配关系，即衍生出一套新的社会沟通系统。对照任务中两名被试事先被告知图形与字符之间的匹配关系，流程与实验任务相同。运用基于近红外成像的超扫描技术，同时采集两个被试的右侧前额叶皮层（PFC）和右侧颞顶联合区（TPJ）的脑活动，采用小波分析方法计算脑间活动同步性（INS），考察实验任务沟通成功、沟通失败以及对照任务条件下 INS 的组间差异，探讨 INS 与行为指标间的相关。

结果与讨论

行为学结果发现，实验任务中沟通成功组的共享意图高于失败组，共享意图与协调期沟通成功率存在正相关关系。实验组协调期两名被试右侧颞上回的 INS 显著增加，高于对照任务；且沟通成功组的 INS 高于沟通失败组；此外，INS 与共享意图和沟通成功率均存在正相关关系；通过中介分析发现，INS 在共享意图对于沟通成功率的影响中发挥中介作用。

结论

脑间同步性能够作为一个稳定的神经生物学指标，区分和预测新的社会沟通系统成功形成与否。

致谢

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Gender differences in the effect of perceived stress on brain morphology

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Objective

Several of the brain regions susceptible to increased levels of stress (i.e., hippocampus and prefrontal cortex) are also known to undergo disproportionate decline. Although gender differences have been identified as key factors and main characteristics of stress-related anxiety and associated clinical mental disorders, the neural mechanisms underlying these differences remain unknown. The objective of this study is to investigate the influence of gender difference in Grey Matter Volume (GMV) changes caused by perceived stress.

Methods

The MPI-Leipzig Mind-Brain-Body dataset was obtained via OpenNeuro, its accession number is ds000221. Eight men and 8 women were selected for the High-stress group with a high Perceived Stress Questionnaire (PSQ) score of 50 or above, Low-stress group also involved 8 men and 8 women who had a score of 20 or less. All participants were between 20 and 35 years of age and contained a structural quantitative T1-weighted image. In order to identify the neuroanatomical basis of gender differences in perceived stress, we conducted a Voxel-Based Morphometry (VBM) study and Two-Way ANOVA analysis to compare the GMV between subject groups. The resultant F-maps were thresholded with voxel $p < 0.001$, cluster $p < 0.05$ (Gaussian Random Field theory (GRF) correction for multiple comparisons).

Results & Discussion

Among all participants, the main effect of perceived stress in GMV is significant, there are 3 clusters of greater GMV in High-stress group than Low-stress group, including right brainstem（peak intensity F=4.595）, left brainstem（peak intensity F=4.327）, and left middle frontal gyrus（peak intensity F=3.444）. The main effect of gender in GMV is also significant, male has 7 clusters of greater GMV spreading over left cerebellum（peak intensity F=3.160）, right occipital lobe and cerebellum（peak intensity F=3.581）, right fusiform gyrus and temporal lobe and occipital lobe（peak intensity F=4.324）, left inferior frontal gyrus and precentral gyrus（peak intensity F=4.280）, right cuneus and occipital lobe（peak intensity F=3.908）, right frontal lobe and parietal lobe（peak intensity F=4.281）, left and right middle frontal gyrus and paracentral lobule（peak intensity F=3.560）, also one cluster of smaller GMV in right inferior frontal gyrus and medial frontal gyrus（peak intensity F=3.981）than female. The interaction effect of stress and gender is significant, in terms of changes in GMV caused by the stress, it affected men more than women, with 4 significant brain regions exist, including left middle frontal gyrus（peak intensity F=3.404）, right occipital lobe and cuneus（peak intensity F=3.583）, left postcentral gyrus and

precentral gyrus（peak intensity F=4.596）, and right postcentral gyrus and precentral gyrus（peak intensity F=4.249）.

Conclusions

There are gender differences in the brain morphological changes induced by perceived stress, and the effect is greater in men than in women, which is manifested by elevated GMV in some frontal and occipital lobes. The current study illustrates the neural mechanisms underlying gender differences in stress, and it has implications for developing more effective treatment strategies tailored to each gender.

Acknowledgement: This work was supported by the NSFC (32071086).

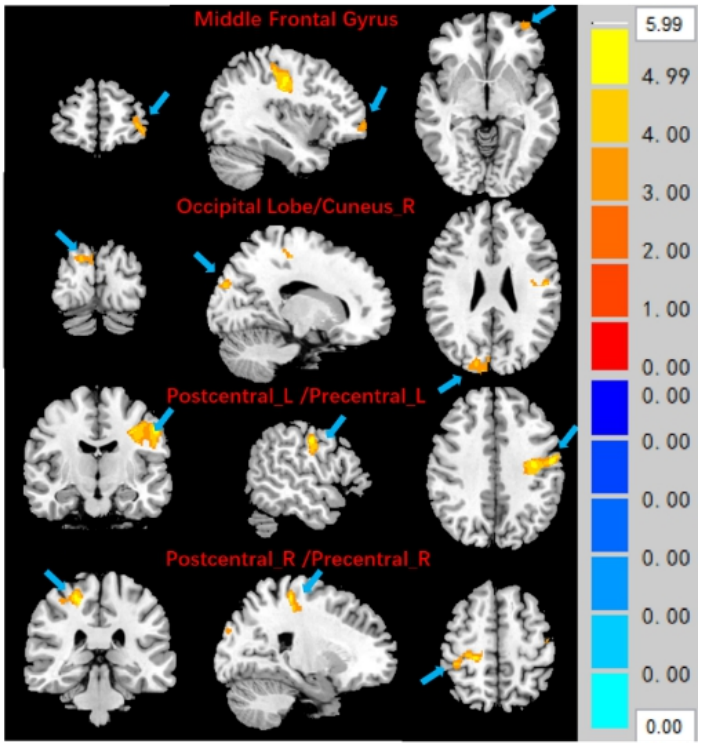


Figure. Interaction effect of gender and disease in GMV

Attention modulation on the perception of others' vocal pain

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Objective

Pain is typically expressed through various sensory (e.g., visual and auditory) modalities: the human voice conveys information about social and affective communication. While the empathic responses to others' pain in the visual modality are modulated by top-down attention constraints, it remains unclear whether empathy for such expressions in the auditory modality also involves such top-down modulation mechanisms. Therefore, the present study investigates how neural correlates of empathic processes to others' vocal pain are modulated by the task-instructed attention manipulations.

Methods

Thirty-six participants completed the following three tasks: (1) Pain Judgment Task, in which participants were instructed to pay attention to pain cues in vocal stimuli, (2) Gender Judgment Task, in which participants were instructed to pay attention to non-pain cues in vocal stimuli; (3) Passive Listening Task, a control task in which participants were instructed to passively listen to the vocal stimuli without any required response.

Results & Discussion

The earlier frontal-central N1 response to either others' painful or neutral voice was greater in the Pain Judgment Task than in the other two tasks, suggesting a general attention modulation on the bottom-up sensory processing of vocal stimuli. The frontal-central P2 responses to others' painful voices was greater in the Pain Judgment Task than in the other two tasks, but not to others' neutral voices, thus suggesting selective attention modulation on the P2 response to others' pain. Late positive complex (LPC) to others' painful and neutral voices differed significantly regardless of task manipulations, thus suggesting empathic pain modulation on LPC response.

Conclusions

All these results demonstrated top-down attention modulation on affective sharing responses others' vocal pain, but not on cognitive appraisal process of others' vocal pain.

Acknowledgment

This work was supported by the Ministry of Education in China, Humanity and Social

Science Youth Foundation Project (19YJC190016).

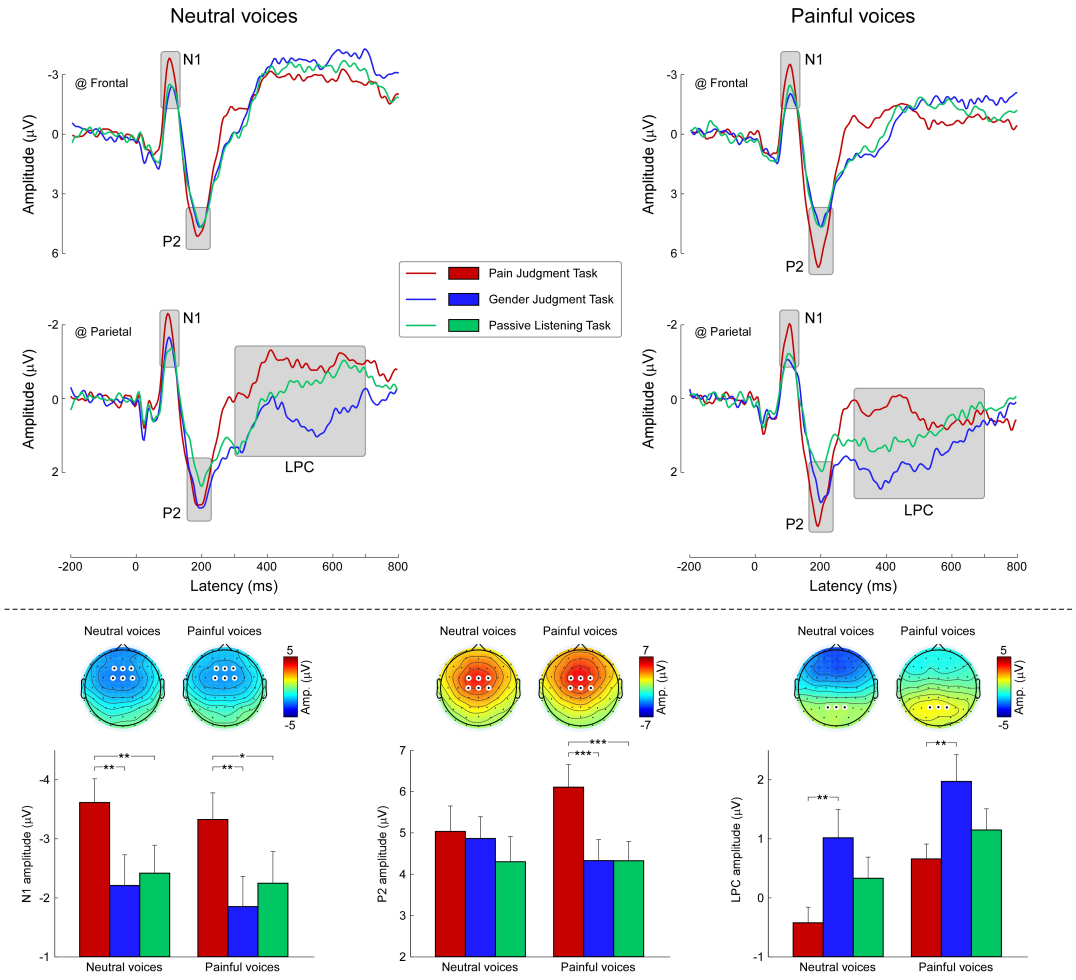


Figure 3. Neural responses to neutral and painful voices in three experimental tasks

ERP waveforms and scalp maps were elicited by neutral voices (left panel) and painful voices (right panel) in the Pain Judgment Task (red color), Gender Judgment Task (blue color), and Passive Listening Task (green color). Amplitudes of ERP components were compared between these three tasks. The electrodes used to estimate the ERP amplitudes were marked using enlarged white dots on the corresponding topographic distributions that were obtained by averaging across task conditions for neutral and painful voices respectively. Data are expressed using Mean ± SEM. *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.

Brain gray matter structures associated with trait impulsivity: A systematic review and voxel-based meta-analysis

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Objective

Trait impulsivity is a multifaceted personality characteristic that contributes to maladaptive life outcomes. Although a growing body of neuroimaging studies have investigated the structural correlates of trait impulsivity, the findings remain highly inconsistent and heterogeneous. Herein, we performed a systematic review to depict an integrated delineation of gray matter substrates of trait impulsivity and a meta-analysis to examine concurrence across previous whole-brain voxel-based morphometry studies.

Methods

We performed a literature search for whole-brain studies if they investigated the neural correlates of trait impulsivity in healthy individuals on voxel-based gray matter volume (GMV). The database was constructed based on peak coordinates for brain structural alterations and corresponding effect sizes. Subsequently, we performed an anisotropic effect-size seed-based d mapping meta-analysis to identify the brain areas underlying trait impulsivity and the clusters modulated by demographic features.

Results & Discussion

A total of 14 whole-brain articles were included in the voxel-based meta-analysis. Trait impulsivity was negatively correlated with regional GMV in four clusters, including the right orbitofrontal cortex, left superior frontal gyrus, right anterior midcingulate cortex, and left middle frontal gyrus, and those regions may set as the brakes. In contrast, GMV alterations in the right superior temporal gyrus/temporal pole, left inferior frontal gyrus, and right postcentral gyrus were positively associated with trait impulsivity as propellers. Age modulated the correlation between trait impulsivity and GMV in the left middle frontal gyrus, left orbitofrontal cortex, and right anterior midcingulate cortex. The association in the left superior temporal gyrus/heschl gyrus, left orbitofrontal cortex, and right middle temporal gyrus was modulated by the gender ratio.

Conclusions

To the best of our knowledge, this is the first meta-analytic investigation of the brain structural correlates of trait impulsivity and advances understanding of neural mechanisms underlying trait impulsivity. The findings may have practical implications in the clinical diagnosis of and intervention for impulsivity-related disorders.

Acknowledgement: This work was supported by the NSFC (31800963, 81621003, 82027808 and 81820108018).

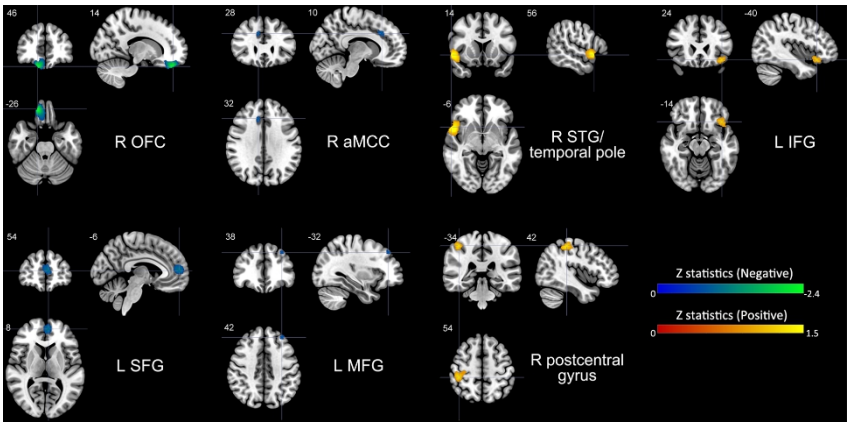


Figure 1. Brain regions where the volumetric GM alterations linked with trait impulsivity. Clusters were exhibited in the sagittal, axial, and coronal planes at voxel-wise $p < .005$, $z > 1$, and cluster size >10 voxels. Regions with negative correlates were shown in blue or green and positive correlates in red or yellow.

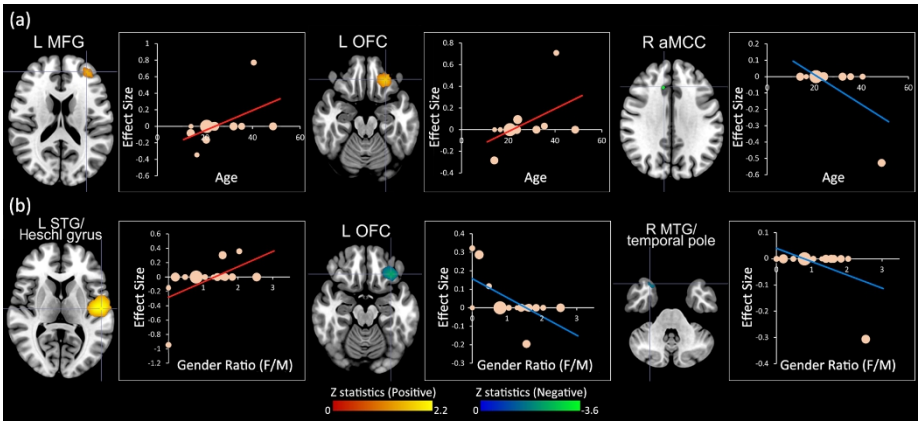


Figure 2. The correlations between the demographics and GMV alteration underlying trait impulsivity. (a) Age modulated impulsivity-GMV associations; (b) gender modulated impulsivity-GMV associations. Clusters were displayed in the axial plane at voxel-wise $p < .0005$, $z > 1$, and cluster size >10 voxels. Regions with positive correlates were shown in red or yellow with an upward regression line and negative correlates in blue or green with a downward line. The Z statistics were obtained from the peak of the maximum slope significance of the regression line. In the plot, each study is marked as a dot, and the size of each dot corresponds to the sample size.

Cooperate or aggress? An opponent's tendencies modulate the neural dynamics of interpersonal cooperation

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Objective

Cooperation is a kind of important social interaction. Previous studies have investigated the impact of individual factors on cooperation and outcome evaluation. However, the outcomes of interaction are determined not only by one's own choice but also by the unique combination of two or more parties' choices. Thus, whether the opponent was a good cooperator might influence individual's cooperation and neural response. Here, our study used iterated Chicken game to investigate how a player's behavior and brain activities to outcome influenced by other player's tendency to be cooperative over time.

Methods

40 college students (20 males and 20 females, with an average age of 20.6±1.85) from mainland China participated in this experiment. Participants would complete 600 rounds Chicken game with a virtual opponent. Approximately half the participants played with an opponent whose choices were pre-programmed to be cooperative at a low frequency (20%) or high frequency (80%), these were called competitive and cooperative opponents, respectively. Aside from the restraints of this manipulation, the opponent's choices were presented in random order. The participants were told that they would be paid at the end of the experiment based on how many points they got in the game; the more points they gained, the more they would be paid. There was no any hint of competition.

The experimental procedure for each trial is shown in **Figure 1**.

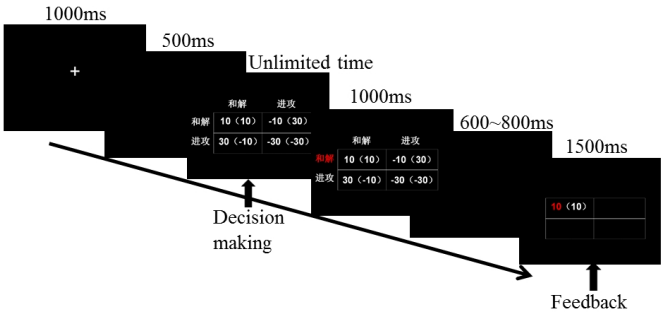


Figure 1. The procedure of trial.

Results & Discussion

Cooperative rate of participants in competitive opponent group was higher than cooperative opponent group. And in the beginning of the game, participants in both group adopted a "tit-for-tat" strategy. However, as the game progressed, when the opponent showed a noticeable tendency to be aggressive, players became more cooperative as a way to limit their losses (as **Figure 2**). ERPs analyses indicated that dFRN amplitude of the cooperative opponent group was significantly negative than that of the competitive opponent group when participants aggressed, and players had a higher P300 in response to their opponent's aggression when their opponent had tended to be cooperative vs. competitive over time (as **Figure 3**). Beyond that, there was a significant negative correlation between the P300 on CA outcome of trial n and the cooperation of trial n+1 also only in the competitive opponent group.

The results showed that people adjusted their choice on their opponent's behavioral tendency and the negative feedback captured more attention than positive feedback.

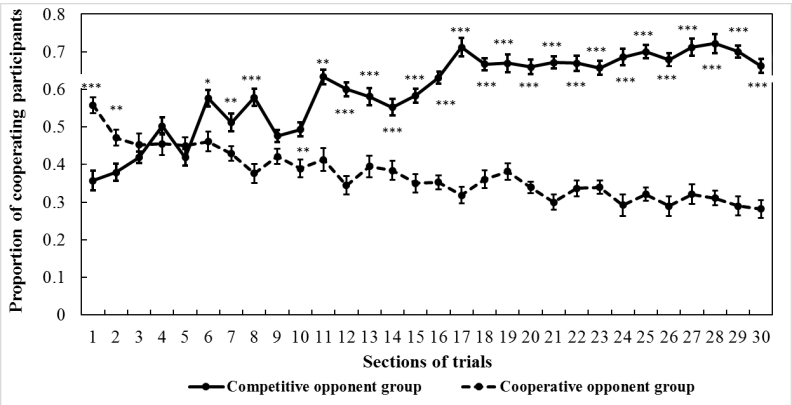


Figure 2. Mean proportion of cooperating participants in Competitive opponent group and Cooperative opponent group over the course of the game.

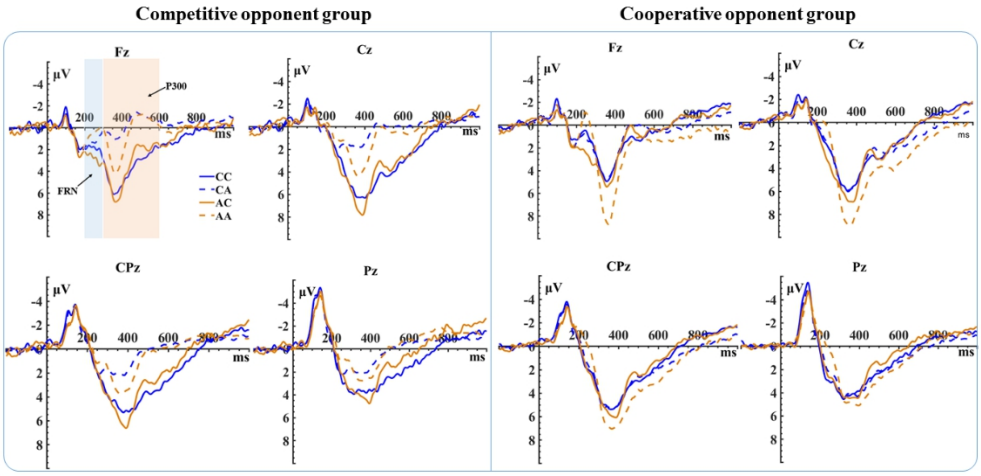


Figure 3. Grand average waveforms of FRN and P300 on the four electrodes as Fz, Cz, CPz and Pz after the presentation of the outcomes.

Conclusions

Participants of competitive opponent group represent more cooperation than cooperative opponent group. In addition, cooperative tendency of opponents has different impact on the dFRN and P300, and in the competitive opponent group, the more positive the P300 induced by the CA outcome in trial n, the lower the cooperative rate in trial n+1.

Independent syntactic representation identified in left front-temporal cortex during Chinese sentence comprehension

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Objective

Syntax is the core of human language faculty. However, the long-standing hot debate is whether syntactic representation in Chinese is independent of semantic representation, since it has no inflectional morphology. To this end, the present study first adopted the syntactic priming paradigm in fMRI to investigate the neural basis of Chinese syntactic representation, because past violation paradigm has its own inherent deficiencies in solving this Chinese problem.

Methods

College students who were native Chinese speakers (N = 22; 10 males; 18–25 years of age) were recruited for this experiment. The experiment used a 2 (Sentence Type: Prime vs. Target) × 2 (Structure: Same structure vs. Different structure) design (see Table 1 for examples). A passive sentence was preceded by either a passive or an active sentence without repeating a verb or a pattern of agent-patient animacy, thus constructing primed and unprimed sentence pairs based on sentence structure. There were 90 pairs of stimuli and each pair included one prime sentence and one target sentence (see Table 1). On each trial, each sentence was presented for 2 s during which the participant needed to press the button box as soon as possible in response to an incorrect sentence (probe sentences). The prime and the target were presented independently of each other to ensure the purity of the priming effect. Every prime-target pair was separated by 1-2 fillers or probe sentences.

Results & Discussion

For each condition in whole-brain analysis, significant activations were found in the front-temporal language network. ROI analysis results (Fig. 1) showed that the activation intensity of targe sentence in the same structure (ST) was lower than that of targe sentence in the different structure (DT) in the LIFG (Fig. 1B), the LpreCG (Fig. 1C) and the LTP (Fig. 1D), but not the LpSTG (Fig. 1E). The results extending previous behavioral and ERP studies on syntactic priming to the localization in cerebral cortex. The LTP, LIFG, LpreCG may be related to the process of building structure, while the LpSTG may integrate syntactic and thematic information.

Conclusions

The present study found syntactic repetition suppression effects in the LTP, LIFG and LpreCG, thus providing the strongest neuroimaging evidence to date that as in Indo-European languages, syntactic representation is independent of semantic representation in Chinese.

Table 1 Examples of experimental trials.

Structure	Prime	Target
Same structure	帽子 被 哥哥 扔掉 了。 hat *bei* elder brother throw away *le* The hat was thrown away by the elder brother.	老头 被 儿女 抛弃 了。 old man *bei* children abandon *le* The old man was abandoned by his children.
Different structure	哥哥 扔掉 了 帽子。 elder brother throw away *le* hat The elder brother threw the hat away.	老头 被 儿女 抛弃 了。 old man *bei* children abandon *le* The old man was abandoned by his children.

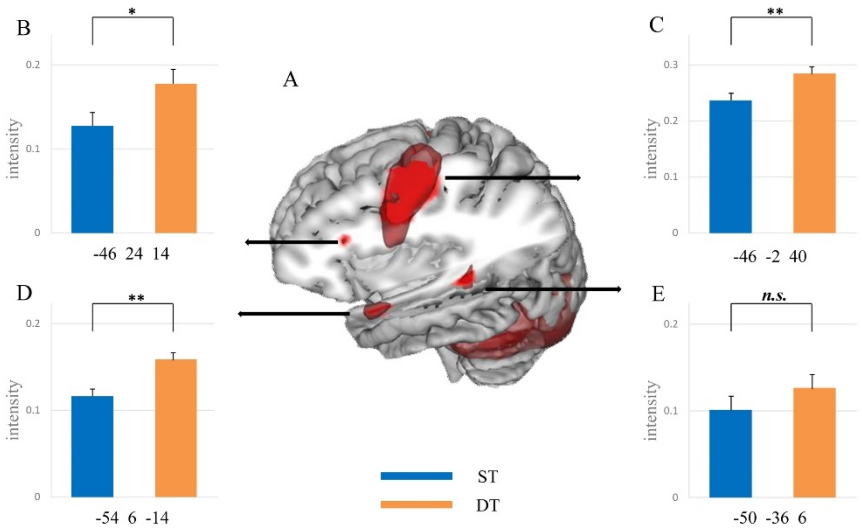


Fig. 2. Mean activation intensities (standard error) for ST and DT in the four ROIs in the left hemisphere.

Myeloarchitectonic asymmetries of language regions in the human brain

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Objective

One prominent theory in neuroscience and psychology assumes that cortical regions for language are left hemisphere-lateralized in the human brain. In the current study, we used a novel technique, quantitative magnetic resonance imaging (qMRI), to examine interhemispheric asymmetries in language regions from a microstructural perspective in the living human brain.

Methods

Two cohorts of participants from Guangzhou (N=65) and Beijing (N=50) were recruited and examined with different MRI scanners to test the myeloarchitectonic asymmetries of language regions. QMRI technique was applied to quantitatively estimate the brain macromolecular tissue volume (MTV) and quantitative longitudinal relaxation time (T1) maps. MTV quantifies myelin volume on the basis that the brain macromolecules are principally cell membranes and proteins, and T1 suggests a mechanism of microstructural variation such as dendrite development, myelination, and oligodendrocytes. Therefore, MTV and T1 quantify cortical myeloarchitecture mapping from the microstructural perspective. The interhemispheric asymmetries of language regions including pars opercularis (POp), pars triangularis (PTr), pars orbitalis (POr), anterior transverse temporal gyrus (Heschl’ s gyrus, HG), planum temporale (PT), and middle temporal gyrus (MTG) were examined. The language skills (phonemic and speech tone awareness) of Beijing participants were tested to elucidating the myelination-behavior relationship. Moreover, we examined whether sex influences lateralization from the microstructural perspective.

Results

We found that the cortical myeloarchitecture of inferior frontal areas including the pars opercularis, pars triangularis, and pars orbitalis is left-lateralized, while that of the middle temporal gyrus, Heschl’s gyrus, and planum temporale is right-lateralized. There was no gender difference in lateralization. Moreover, the leftward lateralization of myelination structure is significantly correlated with language skills measured by phonemic and speech tone awareness.

Conclusion

This study reveals for the first time a mixed pattern of myeloarchitectonic asymmetries, which calls for a general theory to accommodate the full complexity of principles underlying human hemispheric specialization.

Acknowledgments

This work was supported by Guangdong Key Basic Research Grant

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Acupoint-brain (acubrain) mapping: Common and distinct cortical language regions activated by focused ultrasound stimulation on two language-relevant acupoints

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Objective

Acupuncture, taking the advantage of modality-specific neural pathways, has shown promising results in the treatment of brain disorders that affect different modalities such as pain and vision. However, the precise underlying mechanisms of within-modality neuromodulation of acupoints on human high-order cognition, especially language, remain largely unknown. In the present study, we used a non-invasive and easy-operating method, focused ultrasound, to stimulate two language-relevant acupoints, namely GB39 (Xuanzhong) and SJ8 (Sanyangluo), and examined the neuromodulatory effects of FUS by fMRI.

Methods

Thirty right-handed healthy adults were recruited in the study. The study consisted of a focused ultrasound stimulation (FUS) procedure followed by a language localizer task. In the FUS procedure, the spatial-peak pulse-average intensity used at each acupoint (Figure 1) was personalized and set at 10 mVpp below the intensity when participant reported feeling pain. Each FUS run consisted of a total of five 30 s-rest blocks alternated with five 30 s-stimulation blocks. A typical semantic judgment task was adopted for localizing purposes. Participants were asked to judge whether the two characters (one above and one below a fixation crosshair) were synonyms or not. Twelve pairs of Chinese synonymous characters and twelve pairs of non-synonymous characters were used. A block design was adopted, with three 24 s-task blocks alternated with two 20 s-rest blocks. Each task block contained 8 trials. Nine 10mm-radius spherical regions of interest (ROIs), which centered at language-implicated significant peaks of activity in the localizer task, were identified. The neural activity during acupoint stimulation compared with the baseline of rest was measured in each ROI. Participants were also given other language-related tasks, including the Stroop task, phoneme deletion and phoneme counting task, and Chinese reading task, in order to examine whether brain activations evoked by acupoint stimulation were related to language performance.

Results

FUS at GB39 and SJ8 activated overlapping cortical language regions in the left fusiform gyrus, right inferior frontal gyrus (BA44), and right lingual gyrus. FUS at GB39 specifically evoked the brain activity in the left inferior frontal gyrus (BA45), while FUS at SJ8 distinctly activated the left inferior frontal gyrus (BA44) and the right middle frontal gyrus (Figure 2). Activation of the GB39-specific cortical region, left BA45, was positively related to reading ability of the participants. Brain activity

evoked by SJ8 stimulation was positively related to that in the right lingual gyrus during the semantic judgment task.

Conclusion

Focused ultrasound stimulation at GB39 and SJ8 activated common and distinct cortical language regions. Our findings provide a major step toward within-modality acupoint-brain mapping and shed light on to the potential use of FUS as a personalized treatment option for brain disorders that affect high-level cognitive functions.

Acknowledgments

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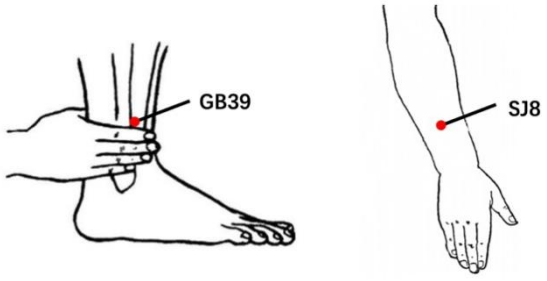


Fig. 1. Anatomical locations of the two acupoints.

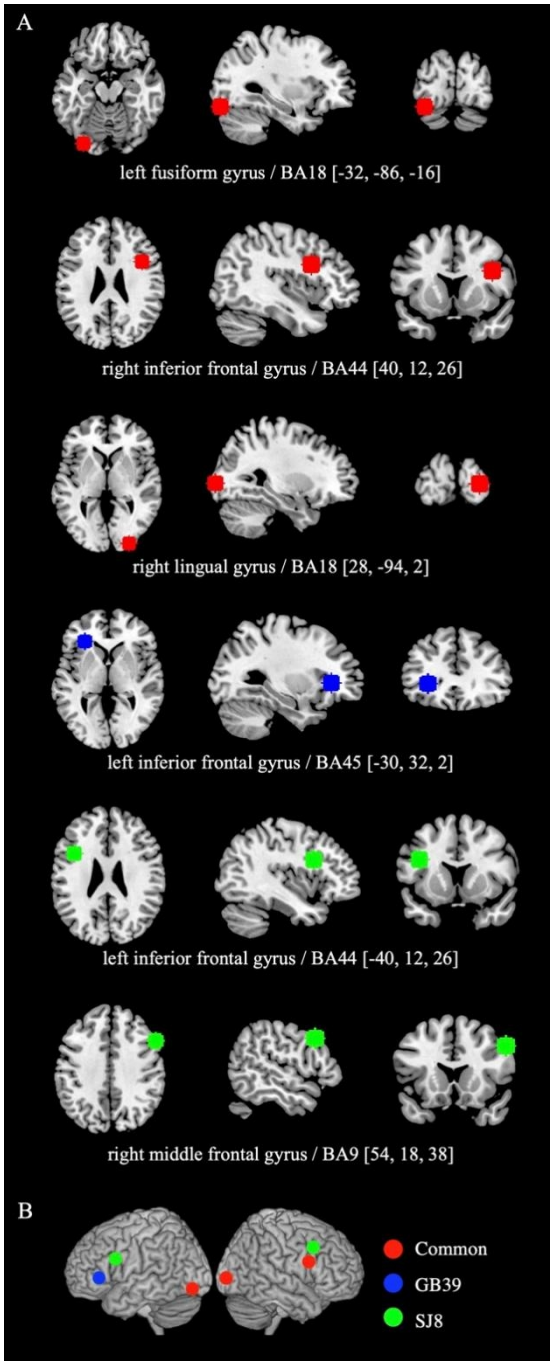


Fig. 2. Cortical language regions activated during FUS. (A) Axial, sagittal, and coronal views. (B) Lateral view. Overlapping cortical language regions activated during GB39 and SJ8 stimulation are indicated in red. Distinct regions activated by GB39 and SJ8 stimulation are indicated in blue and green respectively.

Superior emotional regulating effects of creative cognitive reappraisal: An ERP Study

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Objective

Cognitive reappraisal is a common strategy in emotion regulation. Effective emotion regulation strategy is helpful for individuals to better adapt to social environment and various problems encountered in their own development. Cognitive reappraisal is one of the most important strategies for psychological reappraisal. It refers to changing the person's understanding and understanding of the current situation in order to change the emotional effects of the situation, especially the negative effects. For example, People can alter the negative emotional experience that is evoked by reevaluating an unpleasant, stressful stimulus (such as a picture of a snake) (" This is not a poisonous snake "or" This is just a snake on display in a glass case "). In view of the importance of cognitive reappraisal in emotion regulation and psychotherapy, there have been a lot of studies on cognitive reappraisal. Most studies focus on the effect of emotional regulation of cognitive reappraisal and the comparison between different strategies of cognitive reappraisal. Only a few studies have shown that the key role of creative insight in reappraisal and presents a novel and highly efficient reappraisal strategy. And it's not clear the characteristic in EEG of creative reappraisal.

Methods

16 right-handed students were recruited as paid volunteers through the university's bulletin board system. The participants were tested individually and viewed in 96 unpleasant IAPS pictures. We provided participants with three types of well-prepared reappraisal sentences for unpleasant IAPS pictures, including creative reappraisals, ordinary reappraisals, and objective descriptions of the images. For ERP data, We focus on LPP components and EEG frontal asymmetry.

Results & Discussion

The ERP results showed that compared with ordinary reappraisals, creative reappraisals and objective descriptions elicited an increase in the amplitude of Late Positive Potential (LPP). And the Behavioral results that compared with ordinary reappraisals and objective descriptions, creative reappraisals had a higher emotional valence rating, which means that the emotions induced by negative pictures with creative reappraisals were positive emotions.

Conclusions

the creative cognitive reappraisal after being tried for negative pictures evoked strong emotions for the subjective assessment of positive emotions, namely cognitive reappraisal and other creative cognitive reappraisal compared to traditional , with more good emotion regulation effects.

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Acute stress changes the computational substrates of unaffected third parties

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Objective

When confronted with violations of justice, the human may be motivated not only to punish the violator but also to help the victim. Acute stress has been shown to modulate the preference for punitive and helpful actions. Whereas the neural mechanisms and the computational substrates by which stress influences the preference are unclear. Using a third-party intervention paradigm, we evaluate participants' preferences on the third-party punishment and helping behaviors following exposure to physical stress in a functional magnetic resonance imaging (fMRI) study.

Methods

Forty-three right-handed male volunteers were recruited and randomly assigned to be in either the stress condition (CPT) or the control condition. Participants' affective states, heart rate, and salivary cortisol were repeatedly measured throughout the experiment. Stress induction involved a cold pressor task (CPT) wherein subjects submerged their left hand to the wrist in 0–4°C ice water for 3 consecutive minutes[36]. If a participant failed to complete the CPT, they were excused from the study. The control participants submerged their left hand in warm water (35~37°C) for 3 consecutive minutes. In the third-party intervention game, the participants, as an "irrelevant" third party, could choose whether to sacrifice their own interests to help the victim or punish the transgressor.

Results & Discussion

Results showed that stressed individuals typically prefer to help rather than punish, and the reduced punishment concomitantly with a diminished amygdala sensitivity to inequity and an increased amygdala-ventromedial prefrontal cortex (VMPFC) functional connectivity. These results reveal the early decision of punishment associated with the initial reactive emotional response of limbic system and the emotion regulation of the cortical area. Furthermore, we found that stressed individuals employed stronger dorsolateral prefrontal cortex (DLPFC) and anterior cingulate cortex (ACC) activities respectively when weighing the willingness and the severity between punishment and help relative to the control group. Simultaneously, when focusing on the reduced punishment, we found the individuals in the stress group compared to the control group have a stronger activation in the DLPFC, posterior cingulate cortex (PCC), and the right temporal-parietal junction (rTPJ) in those options of punishment. Together, our results indicate that stress may suppress executive control-based punishment responses aiming at minimum consumption in the prefrontal regions and promote intuitive helping response for maximum survival

opportunity.

Conclusions

Together, this study applied an economic paradigm and computational modeling to investigate high-level social decision-making and the influence of acute stress. Our results showed that in the unfair situation, stressed individuals typically prefer to help rather than punish, and we found a stronger activation in the executive control, mentalizing, and value computation regions when stressed participants punishing.

Acknowledgement: This work was supported by the Major Project of National Social Science Foundation (19ZDA363), the National Key R&D Program of China (2017YFC0803402) ……

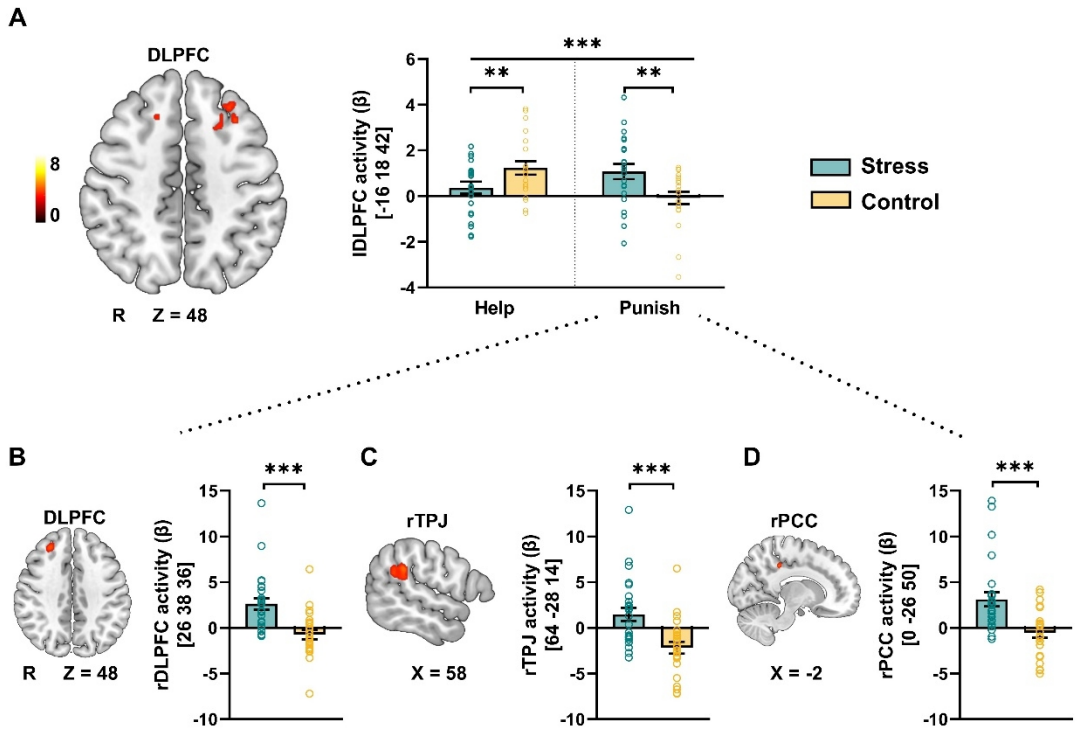


Fig 4. Stress-induced neural activity. (A) Relative to the control group, the stress group has a stronger activation in DLPFC when did the punishment decisions relative to help decisions (Initial whole-brain threshold at P<0.001 uncorrected and cluster corrected at P< 0.05 FWE for left DLPFC). (B~D) Relative to the control group, the stress group have a stronger activation in rDLPFC, rTPJ, and rPCC while did the punishment decision (Initial whole-brain threshold at P<0.001 uncorrected and cluster corrected at P< 0.05 FWE). Brain contrast maps displayed at p< 0.001 uncorrected.

Event-Related Potential Evidence of Audiovisual Benefit Effect of Lexical Tone in Mandarin

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Objective

Can Mandarin lexical tones be perceived better when watching speakers' articulating faces? This paper aims to provide neural evidence that the auditory perception of Mandarin lexical tones can benefit from visual information. It is widely accepted that speech perception is better in audiovisual situation than in auditory-only situation. This effect is referred to as audiovisual benefit, which is usually observed in event-related potentials (ERPs) as reduction of amplitude and latency of the auditory N1 component when visual information is available, and is interpreted as a speeded process due to greater predictability of the auditory information. Unlike consonants, Mandarin lexical tones are less visible and hard to anticipate. It is an intriguing question whether lexical tone processing benefits from visual information. In this study, we compared audiovisual benefit in lexical tone and consonant processing with a syllable judgment task.

Methods

Thirty-nine right-handed Mandarin native speakers participated in 2 tasks. Twenty participants were in tone task and 19 in consonant task. The stimuli were 6 sets of Mandarin monosyllables (bai, dai, tai, bao, dao tao) with 4 lexical tones were presented in audio-only, audiovisual and visual-only modalities. AX same-different discrimination paradigm was applied to tonal and consonant perception task respectively. The participants were given two syllables successively which are only the same or different in lexical tones (in consonants if in consonantal task) and they pressed the spacebar to respond when they detect 2 tones (consonants) are different. The participants were instructed to respond to the task as quickly and accurately as possible and to watch the center of the screen during presenting the syllables. Only the trials of 'the same type' with correct responses will be involved in data analysis.

Results & Discussion

The results showed that lexical tones have the same audiovisual benefit (N1 reduction) as consonants, suggesting that audiovisual reduction might not be completely determined by the visual predictability of the corresponding auditory information. Moreover, we also observed that consonant reduction in N1 is more left-lateralized but tone reduction is bi-lateralized, indicating that audiovisual speech integration is

not constrained to left hemisphere.

Conclusions

Even though lexical tones are not as visually distinctive as consonants, the brain activities show that tonal perception greatly benefits from audiovisual information. Apart from amplitude and latency, the lateralization patterns of reduction effect could be an important indicator for different speech visual cues processing in brain.

Acknowledgement: The study was funded by Shaoxing 330 Scheme for Overseas Chinese Research Elites (China) and Bournemouth University PhD studentship.

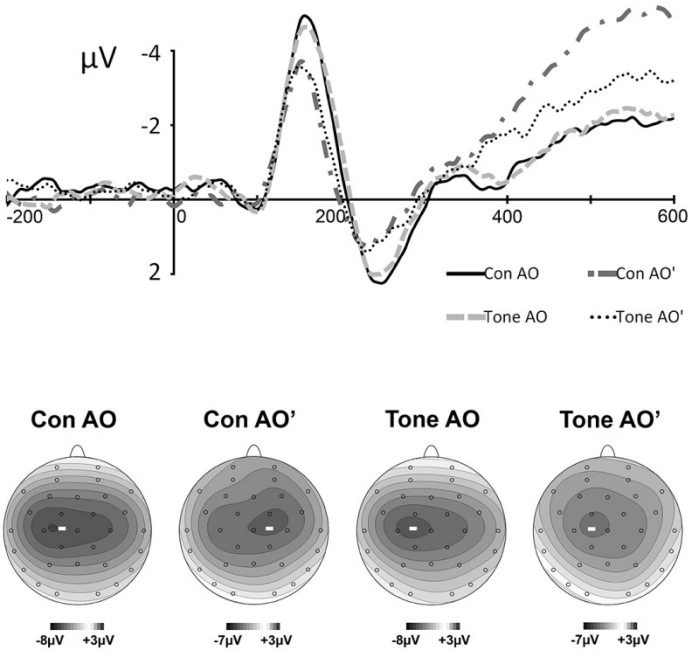


Figure 2. Average ERP waveforms of 8 electrodes (FC5/6, FC1/2, C3/4, CP1/2) of consonant and tone task under AO and AO' (AV-VO) conditions. The topography maps represent the voltage distribution at peak latency of each condition in both tasks.

Therapeutic efficacy of connectivity-directed transcranial magnetic stimulation on anticipatory anhedonia

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Objective
There are currently no effective treatments specifically targeting anticipatory anhedonia, a major symptom of severe depression which is associated with poor outcomes. The present study investigated the efficacy of individualized repetitive transcranial magnetic stimulation (rTMS) targeting the left dorsolateral prefrontal cortex (lDLPFC)–nucleus accumbens (NAcc) network on anticipatory anhedonia in depression.

Methods
This randomized, double-blind, sham-controlled clinical trial (NCT03991572) enrolled 56 depression patients with anhedonia symptoms. Each participant received 15 once-daily sessions of rTMS at 10 Hz and 100% motor threshold. Stimulation was localized to the site of strongest lDLPFC–NAcc connectivity by functional magnetic resonance imaging. The Hamilton Depression Rating Scale (HAMD) was used to measure depression severity, the Temporal Experience Pleasure Scale (TEPS) to measure anticipatory and consummatory anhedonia to specifically measure anticipatory/motivational anhedonia. Event-related potentials (ERPs) during the monetary incentive delay (MID) task were recorded to evaluate the electrophysiological correlates of reward anticipation and response.

Results
Patients in the Real group showed significant improvements in anticipatory anhedonia and general depression symptoms post-treatment compared to the Sham group. The Real group also demonstrated more positive going cue-N2 and cue-P3 amplitude during MID reward trials after treatment. The change in cue-P3 post-treatment was positive correlated with improved TEPS-anti score.

Conclusions
Individualized rTMS of the lDLPFC–NAcc network can effectively alleviate anticipatory anhedonia and improved the reward seeking as evidenced by enhanced MID behavioral performance and more positive going cue-N2 and cue-P3. The lDLPFC-NAcc network play critical role in anticipatory reward and motivation processing.
Acknowledgement: This work was supported by the NSFC (31771222)

Downregulated GPR30 Expression in the Epileptogenic Foci of Female Patients with Focal Cortical Dysplasia Type IIb and Tuberous Sclerosis Complex Is Correlated with 18F-FDG PET-CT Values

2020 年 12 月已被 Brain Pathology（IF=5.568）接受并发表

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Objective:

Focal cortical dysplasia type IIb (FCDIIb) and tuberous sclerosis complex (TSC) are typical causes of developmental delay and refractory epilepsy. G-protein-coupled receptor 30 (GPR30) is a specific estrogen receptor that is critical in neurodevelopment, neuroinflammation, and neuronal excitability, suggesting that it plays a potential role in the epilepsy of patients with FCDIIb and TSC. Therefore, we investigated the role of GPR30 in patients with FCDIIb and TSC.

Methods:

RT-PCR, Western blot, immunohistochemistry, whole-cell patch-clamp recording and 18F-FDG PET-CT were performed.

Results:

We found that the expression of GPR30 and its downstream protein kinase A (PKA) pathway were decreased and negatively correlated with seizure frequency in female patients with FCDIIb and TSC, but not in male patients. GPR30 was widely distributed in neurons, astrocytes, and microglia, and its downregulation was especially notable in microglia. The GPR30 agonist G-1 increased the expression of PKA and p-PKA in cultured cortical neurons, and the GPR30 antagonist G-15 exhibited the opposite effects of G-1. The NF-κB signaling pathway was also activated in the specimens of female patients with FCDIIb and TSC, and was regulated by G-1 and G-15 in cultured cortical neurons. We also found that GPR30 regulated cortical neuronal excitability by altering the frequency of spontaneous excitatory postsynaptic currents and the expression of NR2A/B. Further, the relationship between GPR30 and glycometabolism was evaluated by analyzing the correlations between GPR30 and 18F-FDG PET-CT values (standardized uptake values, SUVs). Positive correlations between GPR30 and SUVs were found in female patients, but not in male patients. Intriguingly, GPR30 expression and SUVs were

significantly decreased in the epileptogenic tubers of female TSC patients, and ROC curves indicated that SUVs could predict the localization of epileptogenic tubers. Taken together, our results suggest a potential protective effect of GPR30 in the epileptogenesis of female patients with FCDIIb and TSC.

Conclusion:

In summary, we found that GPR30 potentially affected epileptogenesis by modulating neuroinflammation and neuronal excitability in female patients with FCDIIb and TSC. In addition, we found that decreased GPR30 expression was positively correlated with hypo-glycometabolism in the epileptogenic foci of female patients with FCDIIb and TSC by analyzing the correlation between GPR30 and PET-CT SUVs. Intriguingly, both GPR30 expression and SUVs were decreased in the epileptogenic tubers of female TSC patients, and SUVs could be used to predict the location of epileptogenic tubers. Therefore, our results offer a potential therapeutic strategy for female patients with FCDIIb and TSC, and show that PET-CT SUVs might be a noninvasive marker to reflect GPR30 expression and the localization of epileptogenic tubers in female patients. However, there are some limitations to this study. The number of human participants in each group was barely acceptable, limiting the universality of our results. Moreover, the specific molecular indicator of PET should be synthesized to image GPR30 and confirm our results in this study.

Female mice lacking ERβ display excitatory/inhibitory synaptic imbalance to drive the pathogenesis of temporal lobe epilepsy

已被 Theranostics(IF=8.579)接收

Zhongke Wang, Ruxin Xie, Xiaolin Yang, Huachun Yin, Xin Li, Tianyao Liu, Yuanyuan Ma, Junwei Gao, Zhenle Zang, Ruotong Ruan, Yang Li, Kaixuan Huang, Qingbo Chen, Kaifeng Shen, Shengqing Lv, Chunqing Zhang, Hui Yang, Maragret Warner, Jan-Ake Gustafsson*, Shiyong Liu*, Xiaotang Fan*

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Objective

Epilepsy is a highly prevalent and drug-refractory neurological disorder characterized by spontaneous recurrent seizures. Estrogen is identified to be proconvulsant and lowers the seizure threshold of female epilepsy. Estrogen receptor β (ERβ) has been proposed to mediate neuroprotection in epilepsy, although the underlying mechanism remains unknown. In this study, we investigated the role of ERβ in the epileptogenesis of female temporal lobe epilepsy (TLE).

Methods

Immunohistochemistry, immunofluorescence, western blots, Golgi staining, ^{1}H MRS and whole-cell patch-clamp were used to evaluate ERβ expression, pathological changes, and synaptic excitation /inhibition (E/I) balance in female TLE patients and ovariectomized (OVX) chronic epileptic mice. Electroencephalogram (EEG) recordings were recorded to evaluate the epileptic susceptibility in OVX WT and ERβ$^{-/-}$ mice. And high-throughput RNA-sequence was performed to identify differential expression genes (DEGs) which can elucidate the potential mechanism of ERβ regulating the seizure susceptibility.

Results

ERβ expression was decreased in the brains of female TLE patients and OVX chronic epileptic mice. ERβ deletion enhanced seizure susceptibility and exacerbated the imbalance of synaptic E/I in hippocampal CA1 area of OVX epileptic mice. In line with these observations, RNA-sequence data further identified glutamine ligase (GLUL) as the target of ERβ involved in regulating synaptic E/I in CA1. Furthermore, ERβ agonist WAY-200070 markedly suppressed epileptic phenotypes and normalized GLUL expression in CA1 region of kainic acid (KA) induced OVX chronic epileptic model.

Conclusions

Our data provide novel insight into the pathogenesis of female TLE, and indicate ERβ provides a new therapeutic strategy for female TLE patients.

Neural Synchronization of compromise in Third Party Punishment: A fNIRS Hyper-scanning Study

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Objective

People need to confront difference in attitudes, intentions, and social or moral standards with other members in group decision-making. How people deal with these differences and what the underlying neural correlates remains unclear[1]. Here we try to explore people deal with the difference between themselves and others' behavior in face-to-face group-based third-party punishment (TPP) with functional Near-Infrared Spectroscopy (fNIRS) based hyper-scanning. We hypothesize that individuals would compromise in such a situation to avoid indulging agents' unfair behaviors and this kind of compromise will be reflected on the changes of behavioral punishment and neural synchronization in the DLPFC and TPJ[2,3].

Methods

One-hundred and twenty college students were recruited and paired into 61 dyads according to the difference of decision preference in TPP. They played as pairs of third parties and made punishment as a group to offers generated by anonymous proposers. If their punishments are the same in a trial, the punishment would be taken effect on the proposer, that is, both of them and the proposer would lose monetary units according to their punishment points; otherwise, the punishment would not be taken effect, and the proposer would be indulged that all of them lose nothing (Fig. A-B). We manipulated the intention and outcome of proposers which resulted in three within-subject types of offers with 54 trials (18 trials each type): Unfair Intention and Fair Outcome (UF) (i.e., the proposer intended to make unfair offers but failed), Unfair Intention and Unfair Outcome (UU) (i.e., the proposer intended to make unfair offers and succeed), and Fair Intention and Fair Outcome (FF) (i.e., the proposer intended to make fair offers and do well). Behaviorally, we measured the punishment for proposers' offers for each dyad in each trial and analyzed how their behavioral difference varies across time. Neurally, we employed two identical LABNIRS optical topography systems to simultaneously collect imaging data from each pair of third parties. For each participant, we used two identical 3×2 and 2×2 optode probe sets, covering the bilateral TPJ and bilateral DLPFC (Fig. C). After down sampling, detecting and correcting data by a discrete wavelet transformation filter, and a principal component analyzing with 80% as the threshold of variance, we identified a frequency band of

interest (i.e. a frequency band from 0.034 Hz to 0.167 Hz, corresponding to the period between 6 s and 29 s) to put into the wavelet transform coherence analysis to calculate the neural synchronization (Fig. D). We focus on the neural synchronization in the time window from decision phase to the following fixation phase.

Results & Discussion

The results showed that the difference of punishment between the third-party dyads decreased in both UF and UU conditions (Fig. E), and the sum of punishment increased in the UU condition, which suggested that dyads compromised to decrease their difference to avoid indulging the proposers' unfair behaviors. More importantly, we identified different behavioral patterns of compromise between UF and UU condition (Fig. F). That is, one third party (leader) held on his choice across time, another third party (follower) decreased the punishment to approach the leader in the UF condition but increased the punishment in the UU condition. Neurally, synchronization of rTPJ (channel 6) increased over time in UF condition, but not in UU and FF conditions (Fig. G); whereas, synchronization of lTPJ (channel 4) increased over time in the UU condition, but not in UF and FF conditions (Fig. H).

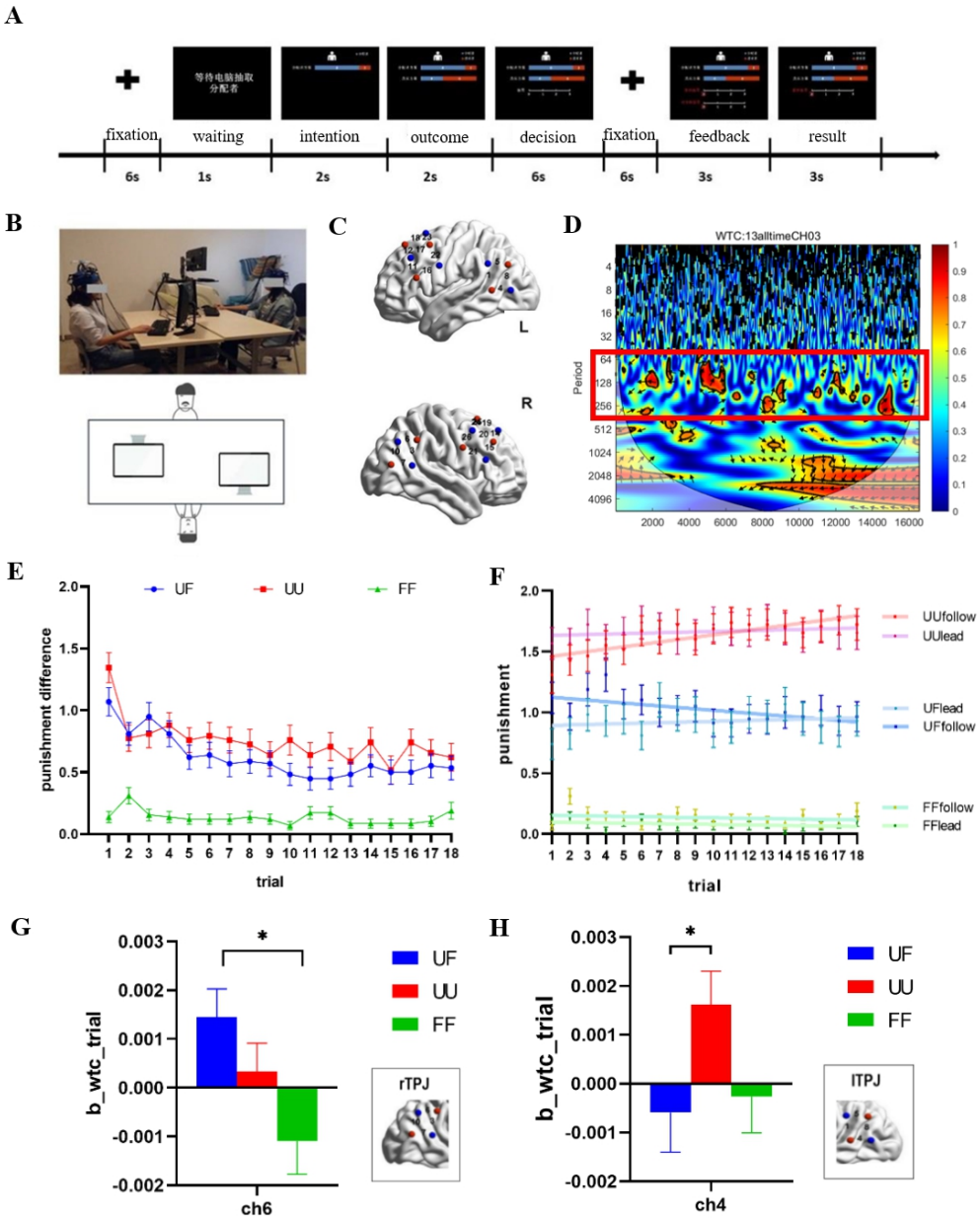
These findings suggest that the third-party dyads exactly show compromise in punishing unfair behaviors in face-to-face interaction, but show different patterns when the unfairness is attempted or actual. The neural findings suggest that left and right TPJ play different roles in processing the attempted and actual unfairness. That is, the right TPJ might be more sensitive to processing difference between own and others' attitudes toward unfair intentions, especially when the intention is not taken actual effect; while the left TPJ seems to assist dealing the difference between third-parties' attitudes toward actual unfair behaviors. The time course of neural synchronization also provide evidence for interbrain plasticity, the basis of the facilitation effect of social interactions on learning. However, this is only our initial data analysis. We plan to conduct more analysis for neural data through cross-channel or cross-phase methods to explain the different behavioral patterns.

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A
fixation
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intention
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decision
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6s
1s
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3s
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B
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WTC:13alltimeCH03
Period
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punishment difference
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UF
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FF
lTPJ
b_wtc_trial
ch4

The development of computational mentalizing during social cooperation from childhood to adulthood

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Objective

Theory of mind (ToM) is a fundamental skill for human social interaction. Behavioral and neuroimaging studies have found that the advanced forms of social perspective-taking (other's intention and belief) are associated with increased involvement of mentalizing regions, including the left temporo-parietal junction and the right dorsolateral prefrontal cortex. Here we combined game theory and computational modeling to explore how mentalizing abilities develop from young children to adults.

Methods

Seventy-seven young children, 127 adolescents, and 135 young adults were recruited in the current study to complete a repeated version of the prisoner's dilemma with real-time feedback. We employed a fictitious play learning algorithm to model participants' behavior during the game decomposing the distinct computational subcomponents of mentalizing process.

Results & Discussion

We observed an increase in cooperative behaviors with age. Unlike children, adolescents and adults acted as conditional cooperators, increasing their cooperation rate quickly when partners became highly cooperative while decreasing when partners became defective. Participants were more likely to deploy a more complex computational algorithm as their age increased. Young children adopt a simple reward reinforcement learning rule rather than a complex model. Although both adolescents' and adults' behavior can be described by the same advanced computational model, they differed in the weight of each mental component. As age increased, individuals became highly dependent on second-order beliefs to infer other's intention during cooperative interaction.

Conclusions

As age increased, individuals used a more complex algorithm to calculate the potential risks and benefits during interpersonal interactions and showed a more sophisticated behavior pattern. The results echoed a large number of theoretical work and empirical neuroscience findings. Decomposing first- and second-order beliefs of inferring partner's mental states with computational modeling, our study further provided a more precisely quantified developmental trajectory of mentalizing process from early childhood to adulthood.

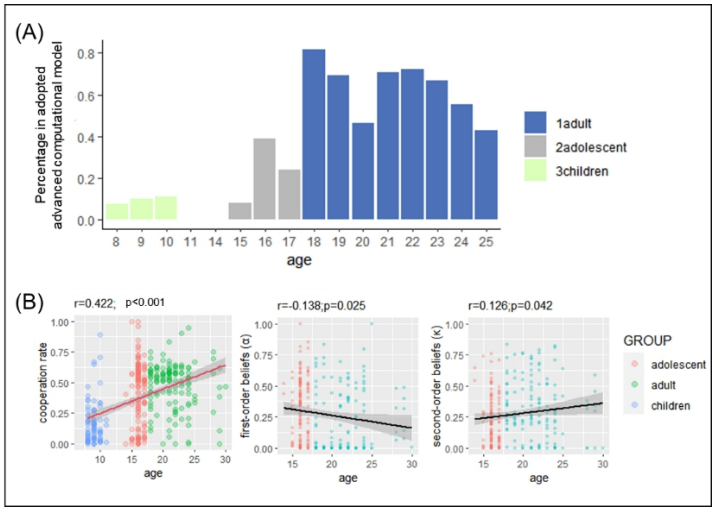


Fig 1. The percentage of adopting advanced computational algorithm increased with age (A). cooperative behaviors increased with age (B left). High level theory of mind components was captured in adults than in adolescents (B middle and right).

Genes in immune pathways associated with abnormal white matter integrity in first-episode and treatment-naïve patients with schizophrenia

Background

Previous studies have inferred a strong genetic component in schizophrenia. However, the genetic variants involved in the susceptibility to schizophrenia remain unclear.

Aims

To detect potential gene pathway and network associated with schizophrenia, and to explore the relationship between common and rare variants in these pathways and the abnormal white matter integrity in schizophrenia.

Method

100 first-episode treatment-naïve patients with schizophrenia and 140 healthy controls were included. A network-based analysis was carried out on the data collected from the Psychiatric Genomics Consortium Phase I (PGC-I). By using our genome-wide association study (GWAS) and whole exome-sequencing (WES) datasets, a gene-set analysis was employed to detect the associations between the combining effects of common and rare genetic variants and abnormal white matter integrity in schizophrenia.

Results

Patients had significantly reduced functional anisotropy (FA) in the left and right anterior cingulate cortex, left and right precuneus and the extra-nuclear (t =4.61~5.10, P_{FDR}<0.01) compared to controls. Generated from the co-expression network analysis of the PGC-1 summary statistics of schizophrenia, a subnetwork with 207 genes associated with schizophrenia was identified (P <0.01), and 176 out of the 207 genes were co-expressed in four gene modules. Functional enrichment analysis for genes in each module revealed that the Yellow module was enriched with highly co-expressed innate immune response genes. Furthermore, rare variants of the enriched genes in the Yellow module were associated with reduced FA in the left anterior cingulate cortex (p =0.006; p_{adj} = 0.024) in patients only.

Conclusions

Pathogenesis of schizophrenia may be contributed substantially by genes involved in the immune system in the form of pathway and network.

Impacts of aberrant social feedback processing on later memory, social evaluation, and social decision-making in depression

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Background. Depression is associated with aberrant social feedback processing such as anhedonia for positive social feedback and heightened sensitivity to negative social feedback. However, little is known about the impact of these deficits on later memory, social evaluation, and social decision-making in depression.

Methods. We examined brain responses via event-related potentials (ERPs) during the processing of social feedback with different emotional valence and intensity, in individuals with high and low depressive tendencies. Participants then performed a memory test, a social evaluation task, and a money allocation task after a three-day interval.

Results. Participants in the depressive, relative to the control, group showed larger occipital P1 and parietal P3 to negative social feedback (Figure 1), as well as larger frontal feedback-related negativity (FRN) to highly positive social feedback, indicating altered attentional allocation, encoding and anticipation in social feedback processing. After three days of social feedback processing, individuals in the depressive vs. control group recalled negative social feedback with a higher accuracy, while they gave lower evaluation and allocated less money to the senders of highly negative social feedback. Moreover, correlations were found between the ERP and behavioral indices, suggesting the long-term impacts of aberrant social feedback processing on social cognition and behaviors in depression.

Conclusions. Individuals with depressive tendency exhibit negative bias in the anticipation, attentional allocation, and encoding during social feedback processing, which further influences their memory, social evaluation, and social decision-making on the long run. These aberrant biases should be targeted to prevent the development of major depressive disorder.

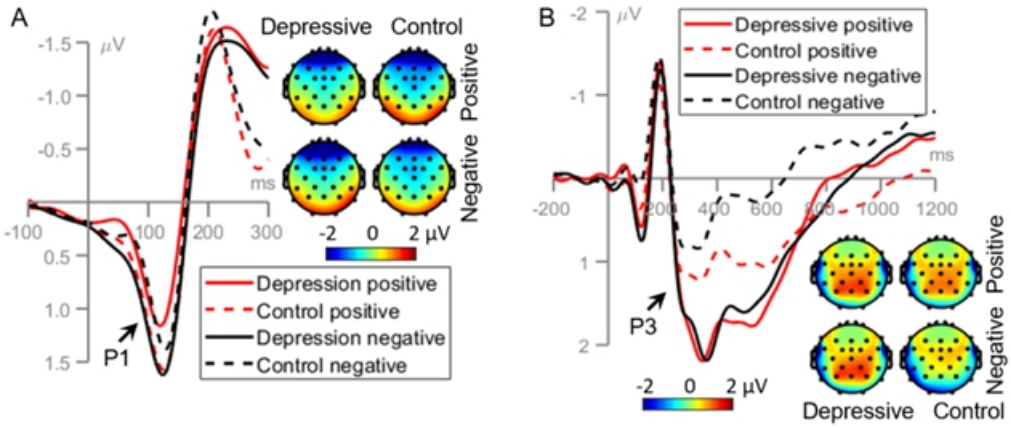


Figure 1. ERP results of the P1 and P3. A, P1 component. Waveforms are averaged across O1 and O2 electrodes. Time window for topographies is from 100 to 150 ms post feedback onset. B, P3 component. Waveforms are averaged across Pz, P3, and P4 electrodes. Time window for topographies is from 300 to 1000 ms post feedback onset.

Compensation in the mirror neuron system for amygdala dysfunction in individuals with higher autistic traits

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The amygdala is a core node in the social brain which exhibits structural and functional abnormalities in Autism spectrum disorder (ASD) and there is evidence that the mirror neuron system (MNS) may functionally compensate for impaired emotion processing following amygdala lesions. Therefore, it is important to further establish this association between the amygdala and MNS in ASD. Healthy individuals with higher autistic traits have sub-clinical characteristics but remain able to cope with the social interaction demands of society. Thus, the MNS may compensate for amygdala dysfunction in them, not only in clinical populations.

Against this background, the present study employed an fMRI paradigm using emotional faces to firstly establish the components of the MNS which respond equivalently to observation, imagination and imitation of face expressions in a large sample of healthy young adults (n = 241), and next to investigate MNS and amygdala responses to dynamic facial expressions in individuals with higher (n = 77) compared to lower (n = 79) autistic traits. Autistic traits were assessed using the Chinese version of the Autism Spectrum Quotient (AQ). In addition, social network indices and recognition memory of emotional faces were assessed.

Conjunction analysis revealed that the inferior frontal gyrus (IFG), superior temporal sulcus (STS), inferior parietal lobule (IPL), supplementary motor area (SMA), insula, precentral gyrus, fusiform and amygdala responded equivalently to observation, imagination and imitation of emotional faces. Further group analysis indicated that individuals with higher compared to lower autistic traits showed reduced left amygdala responses to imitation and enhanced responses in the left STS of the MNS to observation, imagination and imitation. Additionally, functional connectivity between the left amygdala and the STS as well as some other MNS regions was increased in individuals with higher autistic traits, especially during imitation of fearful expressions. Amygdala-MNS connectivity significantly moderated the autistic group differences on recognition memory accuracy for fearful faces and every day social interactions as assessed by social network size, which indicated that increased amygdala-MNS connectivity could diminish the social behavior differences between higher and lower autistic trait groups.

Overall, findings demonstrate that increased associations between the MNS and the left amygdala may occur as compensation for amygdala dysfunction and social problems in individuals with higher autistic traits. Thus, MNS based training may be of potential therapeutic benefit for ASD.
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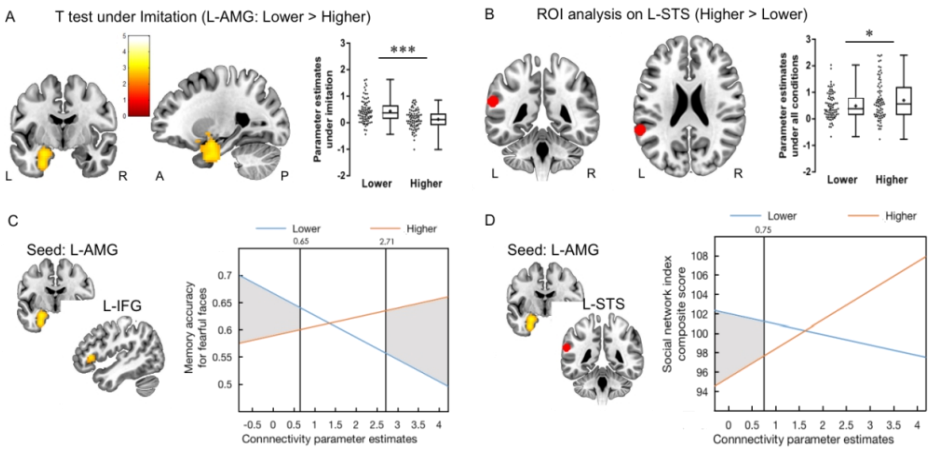


Figure: Group differences in brain activity of the L-AMG (A) and L-STS (B); group differences in functional connectivity of the L-AMG (seed region) with the L-IFG (C) and L-STS (D), as well as the associations with recognition memory accuracy for fearful faces (C) or social network index (D). (* $p < 0.06$; *** $p < 0.001$; Shaded area identifies regions of significance in which behavioral indices differ significantly between two groups at $p <$

Numerosity representation in a deep convolutional neural network: from physical number to perceptual number

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(kzhou@bnu.edu.cn)

Objective

Enumerating objects in the environment (i.e., "number sense") is crucial for survival in many animal species, and foundational for the construction of more abstract and complex mathematical knowledge in humans. Perhaps surprisingly, deep convolutional neural networks (DCNNs) spontaneously emerge a similar number sense even without any explicit training for numerosity estimation. However, little is known about how the number sense emerges, and the extent to which it is comparable with human number sense. Here, we examined whether the numerosity underestimation effect, a phenomenon indicating that numerosity perception acts upon the perceptual number rather than the physical number, can be observed in DCNNs.

Methods

The DCNN model used in the present study is the AlexNet, which consists of five convolutional layers (Conv1 to Conv5) and three fully connected layers (FC1 to FC3). The AlexNet was pre-trained to successfully perform object classification.

The discovery set and zero-connect set contained zero-connected dot-displays with randomly distributed dots, which were used to identity the potential numerosity-selective units in the AlexNet (Fig 1A). The two-connected set contained dot-displays in which two pairs of dots, each connected with a line-segment, formed a dumbbell-like configuration (Fig 1B).

Then in the AlexNet, we examined whether connecting pairs of dots with lines in a dot-display (e.g., stimuli in the two-connected set) reduces the estimate of numerosity.

Results & Discussion

First, consistent with previous findings, reliable number-selective units were found at the layers of Conv3 to FC2, and they also exhibited typical tuning to specific numerosity. However, significant numerosity underestimation effects were only found at the layers of Conv5, FC1, and FC2. That is, the "perceived" numerosity of the dot-displays in the two-connected set was systematically underestimated, as reflected as a rightward shift of the red curve in Fig 2A and upward shift of the red line in Fig 2B. Importantly, there was a trend that the numerosity underestimation effects became progressively much greater as the layer increased.

Conclusions

Our findings suggested that the self-emerged number-selective units at late layers of the DCNN operated on the perceptual number, like humans do. Moreover, this perceptual number sense did not emerge abruptly, rather developed progressively along the hierarchy in the DCNN, shifting from the physical number sense at early layers to perceptual number sense at late layers. Our finding provides important implication for neural implementation of number sense in human brain and advocates

future research to determine whether the representation of numerosity also develops gradually along the human visual stream from physical number to perceptual number.

Acknowledgement: This work was supported by the National Key Research and Development Program of China (2019YFA0709503); National Nature Science Foundation of China (31671133); National Basic Research Program of China (2018YFC0810602); and Fundamental Research Funds for the Central Universities.

Figure 1 Illustrations of the dot-displays stimuli (with 5 dots as exemplars) used in the present study. (A) zero-connected sets. (B) zero-connected-control sets.

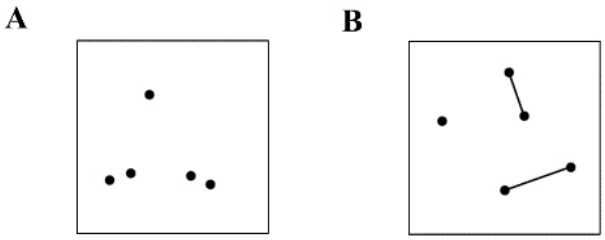
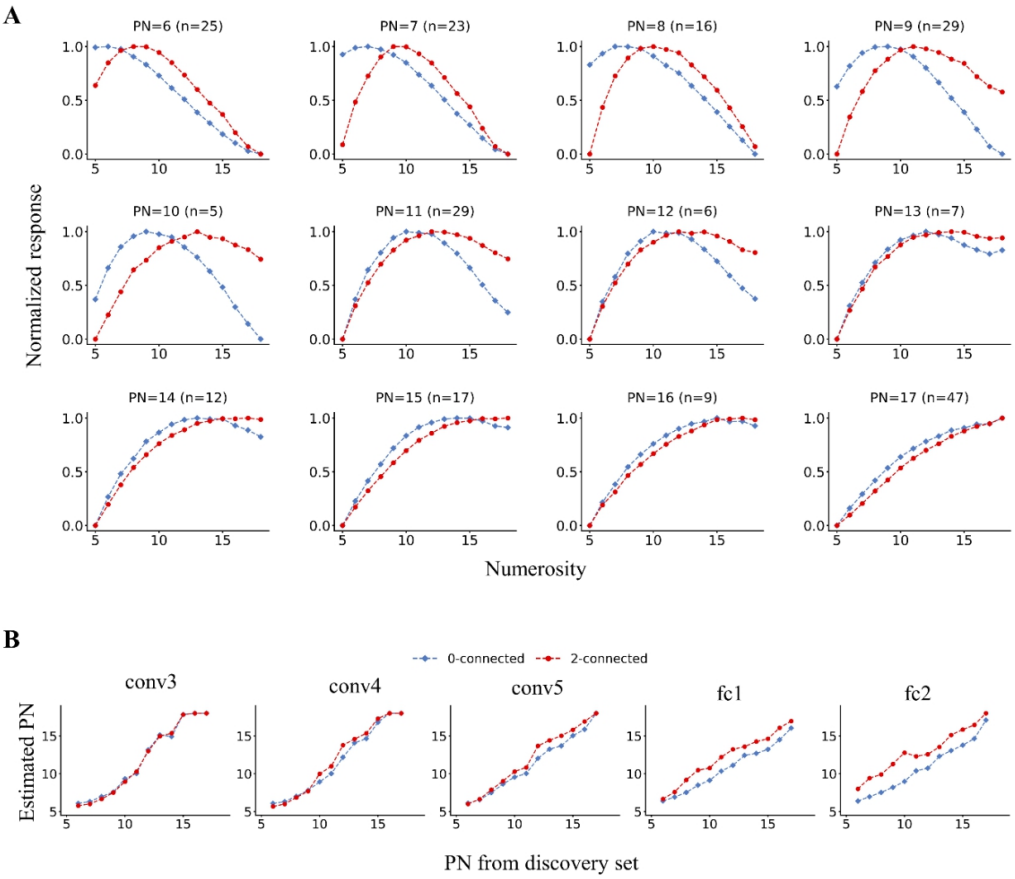


Figure 2. Results of the FC2 layer were shown as an example. (A) Average tuning response of each PN-set to every numerosity of the zero-connected (dark blue line) and 2-connected (red line) sets, respectively. (B) Estimated PN for the zero-connect (dark blue line) and two-connected (red line) sets, respectively, for the Conv3 to FC2 layers.



面孔情绪与种族信息注意捕获的差异：来自行为和 ERP 的证据

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目的

情绪信息和种族信息分别属于面孔中的可变信息和不变信息。面孔识别的分布式模型认为，可变信息与不变信息在加工机制上存在差异。以往研究表明，情绪信息在非注意状态下可以自动加工，而种族信息的加工是否受注意调制还存在争议。基于此，情绪信息与种族信息在注意捕获的程度上是否存在差异？本研究拟采用事件相关电位(event-related potentials, ERP)技术考察面孔情绪信息与种族信息作为分心物时捕获注意的差异。

方法

本研究有效数据共 19 名，采用视觉搜索范式，以 N2pc 和 SPCN 为指标。目标和分心物为情绪（快乐，恐惧）和种族（亚洲人，高加索人）两种维度相结合的刺激，在上、下、左、右四个位置中的随机两个位置呈现。因此，目标与分心物的相对位置又分为四种：目标在中线，分心物在偏侧(MTLD)；目标在偏侧，分心物在中线(LTMD)；目标和分心物均在偏侧(LTLD)；目标和分心物均在中线(MTMD)。被试的实验任务是辨别目标刺激的位置，并按四个方位键进行反应。四种目标在被试间进行平衡。若某一维度与目标一致的分心物诱发的 N2pc 更大，则说明该维度信息更容易捕获注意。

结果和讨论

行为结果显示，当分心物与目标在情绪维度匹配(R-E+)时，反应时更长，正确率更低，表明情绪维度能够捕获注意。ERP 结果显示，MTLD 条件中，230 ~ 330 ms 三种类型的分心物均能诱发 N2pc，而在 350 ~ 450 ms 内只有 R-E+类型的分心物诱发 N2pc。这暗示了早期 N2pc 是对整体面孔的注意捕获，晚期 N2pc 是对面孔情绪信息的注意捕获。此外，LTMD 条件中目标均诱发 N2pc，表明目标刺激捕获了注意。LTMD 和 LTLD 条件中，目标在 350 ~ 550 ms 内均诱发了 SPCN，反映了目标在工作记忆中的巩固维持。且 LTMD 中，R-E+条件目标诱发的 SPCN 显著

更小，说明与目标情绪匹配的分心物干扰目标的记忆巩固和维持过程。

结论

综上，面孔情绪信息与种族信息在注意捕获上存在差异，与种族信息作为分心物相比，情绪信息作为分心物时更容易捕获注意，对目标识别的干扰更大。

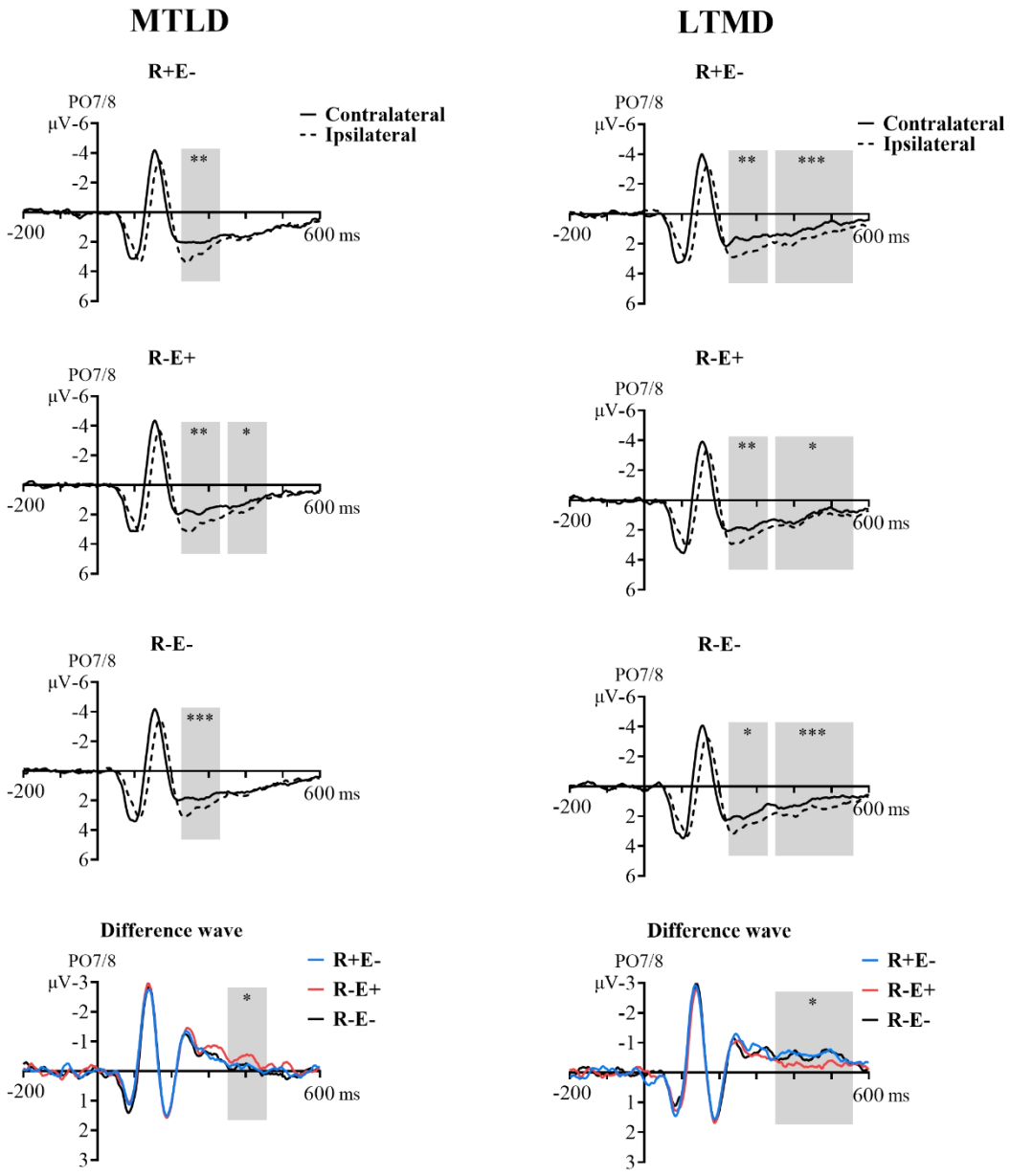


图 1. 三种匹配类型在 MTLD 和 LTMD 条件所诱发的 ERPs 灰色阴影部分分别表示 230 ~ 330 ms (N2pc)、350 ~ 450 ms (N2pc)、350 ~ 550 ms (SPCN)的时间窗。*表示显著性，*代表 $p < 0.05$，**代表 $p < 0.01$，***代表 $p < 0.001$。

Modality-general and specific neural activities in conflict processing

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Objective

This study aims to explore the modality general and/or specific event-related potential (ERP) components in the conflict processing.

Methods

33 subjects were recruited in this study. ERP signals were collected with a 64-channel Brain Products system. The subjects completed both visual and audio Stroop tasks. In the visual Stroop task, they were instructed to respond to the gender of a male/female face, while ignoring the Chinese Character "男" or "女" displayed on the face; in the audio Stroop task, they were instructed to respond to the gender of a voice, while ignoring the spoaken word "nán" or "nǚ".

Results & Discussion

The behavioral results showed significant congruency effects for both visual and audio Stroop tasks. The ERP results showed a significant N450 component (350~450 ms) in the frontal central area in the visual Stroop task. Similarly, in the audio Stroop task we also observed a negative component (300~600 ms) in the frontal central area. To examine whether these two components indicated the same cognitive control mechanisms, we testing their generalization by conducting multivariate pattern analyses (MVPA). The results showed that these two conflicts generalized to each other only in the relatively late period, indicating that the two tasks may trigger specific conflict resolution mechanisms at the early stage, but consume the same control resource at the later stage.

Conclusion

The visual and audio Stroop task trigger modality specific activities at an early stage, but share common components at a later stage.

Acknowledgement: This work was supported by the Scientific Foundation of Institute of Psychology, Chinese Academy of Sciences (Y9CX172005).

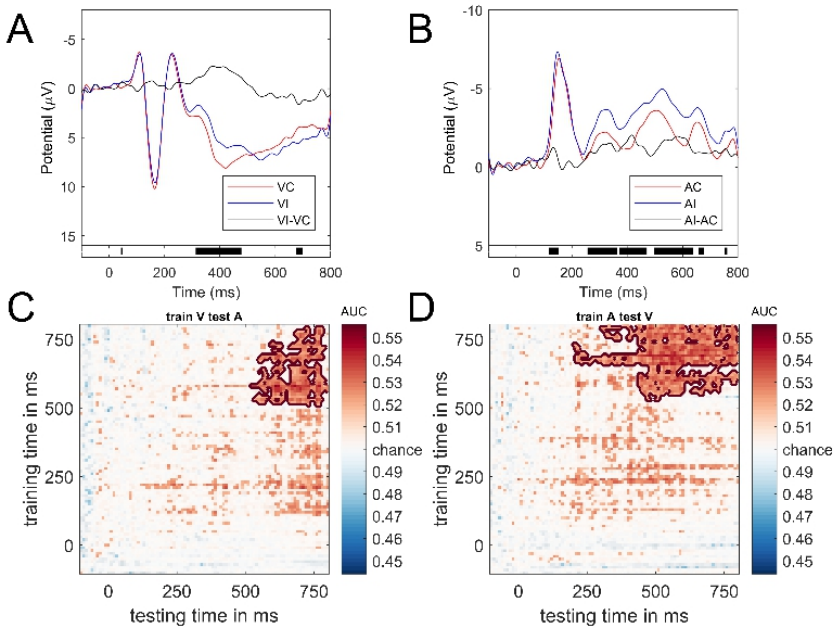


Figure 1. ERP and the MVPA results. (A) and (B) shows the congruency effects of ERPs plotted on FCz in the visual and audio Stroop, respectively. the black lines denote the significant time windows. (C) and (D) shows the generalization between visual and audio Stroop tasks. Abbreviations. V=visual; A=audio; C=congruent; I=incongruent; AUC=area under curve.

To blame or not? Modulating third-party punishment with the framing effect

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Objective

People as third-party observers, without direct self-interest, may punish norm violators to maintain social norms. However, third-party judgment and the follow-up punishment might be susceptible to the way we frame (i.e., verbally describe) a norm violation. Regarding the value of third-party punishment in maintaining a society, investigating its susceptibility to framing techniques and the associated neural underpinnings would be meaningful. We conducted a functional magnetic resonance imaging (fMRI) experiment to investigate the above phenomenon, which we call "third-party framing effect."

Methods

35 right-handed participants were recruited from a university. Participants observed an anonymous perpetrator deciding whether to keep her/his economic benefit while exposing a victim to a risk of physical pain (described as "harming others" in harm condition and "not helping others" in help condition), then they press buttons to indicate how many money units (0~5) s/he would like to pay for punishing that perpetrator

The experiment employed a 2 (frame: harm versus help) × 5 (moral level of a perpetrator's choice) within-subject design. Here, five levels of the moral level factor were: highly pro-helping (90% probability of costing own money to save the victim from a shock), medium pro-helping (70% probability of costing own money), neutral (50%), medium non-helping (70% probability of keeping own money), and highly non-helping (90% probability keeping own money), respectively.

Results & Discussion

Behavioral results show that the participants were more willing to execute third-party punishment under the harm frame, manifesting as a framing effect.

By contrasting the brain activation level under the harm frame and the help frame, fMRI results show that significantly stronger activation in the bilateral insula, left the supplementary motor area, and left middle frontal gyrus. The regression analysis showed that the activation of the bilateral insula significantly covaried with the third-party framing effect size. The above two analyses overlapped in five significant clusters namely the left insula, right insula, the median cingulate and paracingulate gyri, and the superior part of the cerebellum.

By employing the FC-based RVR models, the functional connectivity strength between the above five ROIs for each participant significantly predicted the third-party framing effect size ($r = 0.349$, permutation $p = 0.031$). The strongest

connection was the FC between the left insula (MNI [-36, 6, 0]) and superior cerebellum (MNI [9, -63, -21]).

We proposed that the insula indicates empathy for other's pain and the cerebellum indicates anger in moral behavior. In the harm frame condition, those who have stronger empathy responses to that victim and stronger moral outrage toward the perpetrator choice may feel that the perpetrator's choice is a more serious norm violation and therefore deserves to be punished.

Furthermore, we found that cerebellum activation mediated the relationship between insula activation and the framing effect. that is, anger mediates the relationship between empathy and the framing effect.

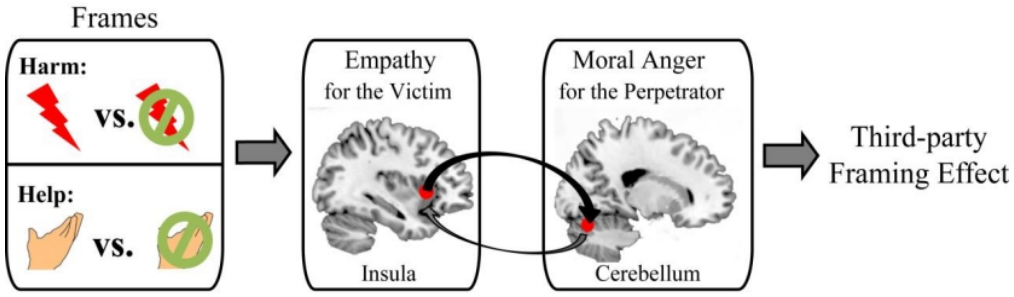
Conclusions

Overall, this study reveals that third-party punishment is susceptible to decision frames, which may help understand why moral standards and moral actions could be flexible and relativistic. Also, this study may broaden the understanding of the framing effect in general.

Acknowledgment: This work was supported by the NSFC (31871109; 31900779; 32071083).

Figure 1.Graphic abstract

Anger for the perpetrator, representing in cerebellum activation mediated the relation between empathy for victim, representing in insula activation and the behavioral framing effect.



Within-group synchronization in the prefrontal cortex associates with intergroup conflict

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Objective

Individuals immersed in groups sometimes lose their individuality, take risks they would normally avoid and approach outsiders with unprovoked hostility. In this study, we identified within-group neural synchronization in the right dorsolateral prefrontal cortex (rDLPFC) and the right temporoparietal junction (rTPJ) as a candidate mechanism underlying intergroup hostility.

Methods

We organized 546 individuals into 91 three-versus-three-person intergroup competitions, induced in-group bonding or no-bonding control manipulation and measured neural activity and within-group synchronization using functional near-infrared spectroscopy.

Results & Discussion

After in-group bonding (versus control), individuals gave more money to in-group members than to out-group members and contributed more money to outcompete their rivals. In-group bonding decreased rDLPFC activity and increased functional connectivity between the rDLPFC and the rTPJ. Especially during the out-group attack, in-group bonding also increased within-group synchronization in both the rDLPFC and the rTPJ, and within-group rDLPFC synchronization positively correlated with intergroup hostility.

Conclusions

Within-group synchronized reduction in prefrontal activity might explain how in-group bonding leads to impulsive and collective hostility toward outsiders

Altered effective connectivity from the insula to the amygdala mediates the relationship between psychopathic traits and the Harm moral foundation

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Objective

Psychopathic traits have been previously demonstrated to be associated with different types of morality. However, the neuropsychological mechanism underlying the relationship between psychopathic traits and morality remains unclear. Combining behavioral measures with resting-state fMRI, this study examined the effective connectivity of psychopathic traits-related brain regions and its association to concern with different moral foundations.

Methods

Levenson Self-Report Psychopathy Scale (LSRP) and Moral Foundation Questionnaire (MFQ) were administered to 78 (29males) college students. Granger causal analysis (GCA) and correlation analyses were applied to investigate the resting-state effective connectivity related to both psychopathic traits and concern with different moral foundations. Mediation analyses were further conducted to investigate whether the effective connectivity mediated the relationship between psychopathic traits and moral foundations.

Results & Discussion

LSRP and primary psychopathy score predicted moral concern with the Harm foundation. Psychopathic traits were associated with decreased effective connectivity from the insula to the amygdala which partially mediated the relationship between psychopathic traits and concern with the Harm foundation

Conclusions

Our findings indicated that the altered insula-amygdala effective connectivity may contribute to less moral concern for harm-related behavior of individuals with elevated psychopathic traits. This study deepened our understanding of the neuropsychological mechanism underlying the relationship between psychopathic traits and morality and may have implications for prevention of higher psychopathic traits individuals from committing serious transgressions.

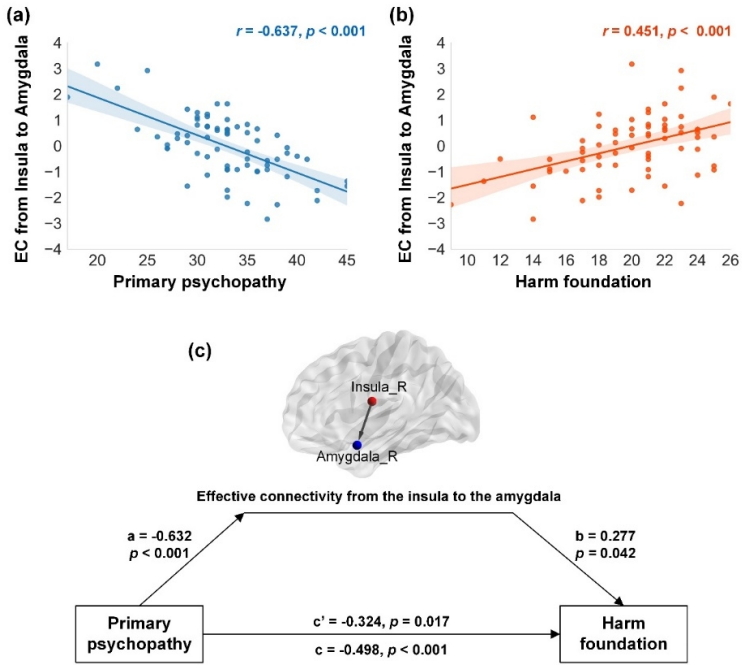


Figure 1. Correlation and mediation analyses (primary psychopathy).

(a) The effective connectivity from the insula to the amygdala was negatively correlated with primary psychopathy. (b) The effective connectivity from the insula to the amygdala was positively associated with concern with the Harm foundation. (c) The effective connectivity from the insula to the amygdala partially mediated the association between primary psychopathy and concern with the Harm foundation.

Functional magnetic resonance imaging of the interaction between central and peripheral processes in Chinese handwriting

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Objective

The neural mechanisms that support handwriting production, an important mode of human communication, are broadly thought to be controlled by two processing streams: a central process responsible for spelling, and a peripheral process responsible for motor output. Lesion studies suggest that the two processes contribute to handwriting independently, but recent behavioral studies suggest that central and peripheral processes interact.

Methods

Using functional magnetic resonance imaging (fMRI), the present study was designed to address these conflicting observations in the context of a task involving copying Chinese characters, in which both a central processing factor (character frequency) and a peripheral processing factor (writing speed) were manipulated.

Results & Discussion

Compared to writing high-frequency characters, writing low-frequency characters showed greater activation of regions thought to support motor processing in writing: the bilateral middle frontal gyrus, inferior parietal lobule, precuneus and cerebellum. Moreover, compared to fast writing, writing at natural speed showed greater activation of regions thought to support visual-orthographic processing: the left lingual gyrus and the right middle frontal gyrus.

Conclusions

These findings collectively showed that manipulation of central processing impacted brain activity in regions for peripheral processing, and *vice versa*. This study is the first to demonstrate functional neuroimaging evidence for interaction between central and peripheral processes, shedding new light on the cognitive architecture of handwriting.

Acknowledgement: This work was supported by the NSFC (31800954).

Nostalgia modulates responses to death-related stimuli: A neurophysiological approach

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Objective

Nostalgia is a self-conscious, bittersweet but predominantly positive social emotion. The emotion of nostalgia serves a variety of adaptive functions such as buffering against death threat. We examined how nostalgia modulates responses to death-related stimuli via a neurophysiological approach.

Methods

Participants were randomly assigned to either nostalgia (N = 31) or control condition (N = 32). Participants in nostalgia condition engaged to a nostalgic event reflection task, while participants in control condition engaged to an ordinary event from their past. Participants then responded to a modified Stroop task that required color judgment of death-related, negative or neutral words, while the electroencephalogram (EEG) was being recorded.

Results & Discussion

Death-related words induced smaller N1 amplitude than neutral words among nostalgic participants but not among control participants. Also, death-related words elicited larger LPP amplitude than neutral words, while the LPP amplitude was attenuated among nostalgic participants than control participants. These findings suggested that nostalgia modulated both early emotional arousal and late regulatory responses to death-related stimuli.

Conclusions

Nostalgia may attenuate emotional arousal caused by death-related stimuli, and moreover, enhance late stage of emotional regulation to death threatening information. The findings shed light on the neural mechanism underlying threat-buffering function of nostalgia.

Association of sleep quality with negative emotions by a combined voxel-based morphometry and resting-state functional connectivity study

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Objective

It was hitherto unknown about neural basis underlying the relation between sleep quality and negative emotions (NES). The present study used a combined voxel-based morphometry and resting-state functional connectivity analysis to investigate the association of NES with sleep quality.

Methods

A total of 339 subjects participated in the study. The NES-related measurements included were the Self-rating Anxiety Scale (SAS), the Self-rating Depression Scale (SDS), the Negative Affect Schedule (NAS) and the Psychosomatic Tension Relaxation Inventory (PSTRI). The principal component of four measures was calculated to indicate negative emotions level. The Pittsburgh Sleep Quality Index (PSQI) was used to assess sleep quality in the past month. In order to determine the brain regions of associated with negative emotions, we performed multiple regression at the whole-brain level in SPM8. Then, the significant encephalic region on GMV analysis was selected as seed regions for functional connectivity analysis. Finally, we used the bias-corrected Bootstrap method in the PROCESS Procedure for SPSS23.0 to determine whether the structure and functional connectivity could explain the relationship between sleep quality and negative emotions.

Results & Discussion

This principal component explained 62.326% of the total variation of the variables. The results revealed a significant positive correlation between the PSQI scores and NES, indicating that the higher PSQI scores showed increased negative emotions. Structural data showed that higher NES scores were associated with a larger rGMV in the left parahippocampal gyrus, right superior temporal gyrus and right postcentral gyrus, which suggested general and specific negative emotions were subserved by different emotional experience. Meanwhile, resting-state fMRI data demonstrated that FC with the three brain regions and the other regions were also significantly associated with NES scores. Furthermore, the GMV of the left parahippocampal gyrus, right superior temporal gyrus and right postcentral gyrus partially mediated the relationship between sleep quality and NES. The FC of the right superior temporal-supplementary motor area and the right superior temporal-right precentral gyrus partially mediated the relationship between sleep quality and NES. Taken together, our results suggest that structural and functional brain variations may be important neurobiological mechanisms of the relationship between sleep quality and NES.

Conclusions

The current study indicated that individual differences in sleep quality were associated with both brain structural and functional connectivity involved in NES.

Acknowledgement: This work was supported by the Research Foundation of Education Bureau of Hunan Province, China (Grant No. 18A029) and the Education Planning foundation of Hunan Province, China (Grant No. XJK20AXL01).

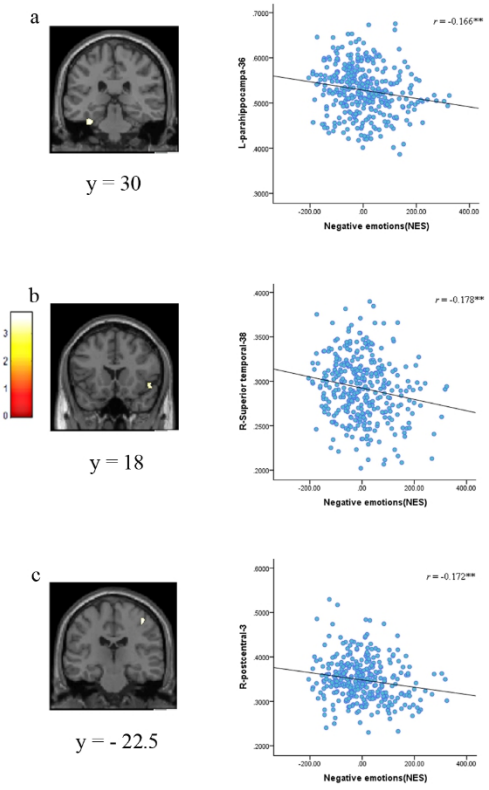


Fig1: Gray matter volume related to NES. After controlling variables of age, gender and total GMV, the left parahippocampal gyrus (a), right superior temporal gyrus (b) and right postcentral gyrus (c) in gray matter volume exhibited significant positive correlation with NES. A scatterplot between NES and the gray matter volume in the left parahippocampal gyrus (a), right superior temporal gyrus (b) and right postcentral gyrus (c) adjusted for age, gender, and total gray matter volume was shown for illustration purpose only. The x-axis of the scatterplots represented the standardized residuals of the total psychological stress score, and the y-axis represented standardized residuals of the GMV values. For standardized residual measures, age, gender and tGMV were regressed out.

EEG denoise Net: A benchmark dataset for deep learning solutions of EEG denoising

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Objective

EEG has been widely used to study brain activity during tasks and resting state. However, raw EEG contains not only brain activity, but also several kinds of noise and artifacts, the most common are ocular, myogenic artifacts. Various traditional denoising techniques have been developed for the removal of artefacts from EEG data. Among them, regression-based methods, adaptive filter-based approaches, blind source separation (BSS) methods are commonly used in current EEG noise reduction. However, these methods are difficult to use in single-channel EEG denoising. Instead, the deep learning (DL) method could be a good solution. Recently, DL methods have been applied to EEG denoising in several studies. However, the lack of preprocessed EEG data and benchmark algorithms has largely limited the development of DL methods for EEG denoising. In this study, we present a publicly available structured dataset, named EEGdenoiseNet, that is particularly suitable for deep network-based EEG denoise studies.

Methods

EEGdenoiseNet contains three main components: data, benchmark networks, and performance evaluation (see **Figure 1**). For the data, we acquired EEG, EOG, and EMG data from several publicly available datasets. Then, we preprocessed the data, and segmented them into segments of 2 seconds; afterward, we visually checked them to ensure they were clean and ready for use; lastly, we acquired 4514 EEG segments, 3400 ocular artifact segments, and 5598 myogenic artifact segments and uploaded the segments of each category to a publicly available repositor on Github named EEGdenoiseNet. With benchmark data, we can generate simulated noisy signals by linearly mixing the EEG segments with EOG or EMG segments according. Then the simulated noisy signals will be randomly assigned to the training set or the test set to training or test our four benchmark denoising model: Fully-connected Neural Network (FCNN); Simple Convolution Neural Network (Simple CNN); Complex Convolution Neural Network (Complex CNN); Recurrent Neural Network (RNN). In the last components, we will use three different performance evaluations to quantitatively test the denoising ability of different models: Relative Root Mean Square Error in the temporal domain ($RRMSE_{temporal}$), the frequency domain ($RRMSE_{spectral}$), and correlation coefficient (CC). Besides, to compare DL based method with the traditional single electrode denoised method, we introduced two

traditional methods: filter and empirical mode decomposition (EMD).

Results & Discussion

To comprehensively compare benchmarks with two traditional methods, we separately plotted the benchmarks of all artifact levels in box graphs (see **Figure 2**), and performed ANOVA analyses. For the ocular artifact removal and myogenic artifact removal, we observed significantly higher performance with the DL-based methods compared to the two traditional methods in $RRMSE_{temporal}$, $RRMSE_{spectral}$, and CC (p <0.001for the six measures, respectively).

Conclusions

We provided a set of benchmark algorithms along with a standardized EEG dataset, which can greatly simplify the comparisons of performance across different DL models. We chose four well-known and relatively basic networks. The performance of these DL models in providing artifact-corrected EEG data was measured using standard measures such as RRMSE and CC. We expect our work to contribute to the DL-based EEG denoising field, in particular, because it standardizes the evaluation of method performance.

Acknowledgement: This work was supported by the NSFC (62001205).

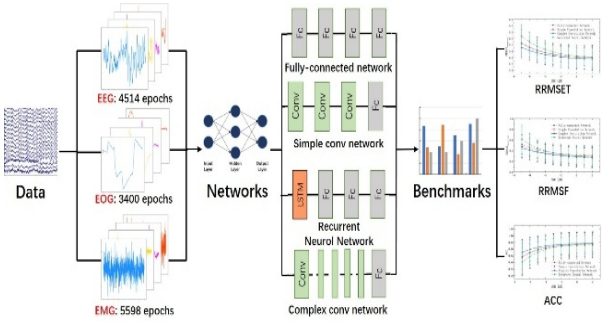


Figure. 1. The framework of EEGdenoiseNet.

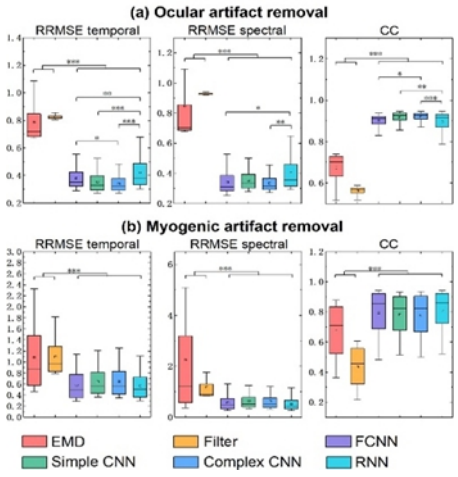


Figure. 2. Performance of four networks and two traditional methods.

Rest-task Modulation of fMRI-derived Global Signal Topography is Mediated by Transient Co-activation Patterns

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Objective

One of the major confounds that limits the cognitive and clinical applications in fMRI is the global signal (GS), which is defined as the spatial average of time varying blood-oxygen-level-dependent signals. Recent resting-state fMRI studies have revealed that the global signal (GS) exhibits a non-uniform spatial distribution across the gray matter. Whether this topography is informative remains largely unknown.

Methods

In this study, we tested rest-task modulation of global signal topography by analyzing static global signal correlation and dynamic co-activation patterns in a large sample of fMRI dataset (n=837) from the Human Connectome Project.

Results & Discussion

The GS topography in the resting-state and in seven different tasks was first measured by correlating the global signal with the local timeseries (GSCORR). In the resting state, high GSCORR was observed mainly in the primary sensory and motor regions, while low GSCORR was seen in the association brain areas. This pattern changed during the seven tasks, with mainly decreased GSCORR in sensorimotor cortex. Importantly, this rest-task modulation of GSCORR could be traced to transient co-activation patterns at the peak period of global signal (GS-peak). By comparing the topography of GSCORR and respiration effects, we observed that the topography of respiration mimicked the topography of global signal in the resting-state whereas both differed during the task states; due to such partial dissociation, we assume that GSCORR could not be equated with a respiration effect. Finally, rest-task modulation of GS topography could not be exclusively explained by other sources of physiological noise or contributions from subcortical areas.

Conclusions

In this study, we demonstrated the informative nature of global signal topography by showing its rest-task modulation, the underlying dynamic co-activation patterns, and its partial dissociation from respiration effects during task states.

Acknowledgement: This work is supported by the Ministry of Science and

Technology of China, National Key R&D Program of China (2016YFC1306700), the European Union's Horizon 2020 Framework Programme for Research and Innovation under the Specific Grant Agreement No. 785907 (Human Brain Project SGA2), the EJLBMichael Smith Foundation, the Canada Institute of Health Research (CIHR), the Start-up Research Grant in Hangzhou Normal University to GN, and Zhejiang University Academic Award for Outstanding Doctoral Candidates to JZ

Vertex Potentials Selectively Reflect Pain Discrimination

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Objective

Laser stimuli elicit a pronounced negative-positive deflection (vertex potentials, VPs) at the vertex electrode in human electroencephalogram (EEG). Recent studies have shown that VPs do not encode between-individual pain sensitivity but reflect stimulus saliency. However, the sensory aspect of pain consists of not only absolute pain sensitivity, but also relative pain discrimination. Here, with three studies, we demonstrated that VPs actually selectively encode pain discrimination.

Methods

In Study 1, 114 participants were recruited (40 males; age [M ± SD]: 20.7 ± 2.3). Laser stimuli with different intensities (3.0J and 4.0J, 15 trials per energy) were delivered and participants were asked to rate the pain intensity using an 11-point (0~10) numeric rating scale. Study 2 recruited 111 participants (54 males; age: 20.9 ± 2.3) who were less sensitive to pain. They completed the same rating task as in Study 1 except that the laser energy was raised to 3.5J and 4.0J. A totality of 225 participants took part in Study 3 (94 males; age: 20.9 ± 2.2). Participants rated the intensity of three types of non-nociceptive stimuli: somatosensory, auditory, and visual. For somatosensation, 30 nonpainful electrical stimuli were used (2mA and 4mA); for audition, 30 pure tones were used (mean intensity rating of 4 and 7 out of 10 in a pilot study); for vision, 30 pictures of round plates (RBG value: [100, 100, 100] and [200,200,200]) were delivered. Discrimination ability was quantified with signal detection theory-based measures (i.e., AUC values).

Results & Discussion

In Study 1, we observed that VPs robustly correlated with pain discrimination quantified with AUC values (N2: Pearson's $r = 0.433$, $p < 0.0001$, $BF_{10} = 10699.420$, Kendall's tau-b $= 0.315$, $p < 0.0001$, $BF_{10} = 25493.625$; P2: Pearson's $r = 0.445$, $p < 0.0001$, $BF_{10} = 21606.443$, Kendall's tau-b $= 0.301$, $p < 0.0001$, $BF_{10} = 8801.485$; see Fig 1 A). In Study 2, the correlation was replicated in and generalized to another group of participants whose pain sensitivity differed from those in Study 1 (N2: Pearson's $r = 0.362$, $p < 0.0001$, $BF_{10} = 222.243$, Kendall's tau-b $= 0.301$, $p < 0.0001$, $BF_{10} = 6438.934$; P2: Pearson's $r = 0.346$, $p = 0.0002$, $BF_{10} = 109.764$, Kendall's tau-b $= 0.288$, $p < 0.0001$, $BF_{10} = 2550.044$). In Study 3, we showed that the relationship between VPs and discrimination ability could only be found in pain, but not in somatosensory, auditory, and visual modalities (see Fig 1 B, C, & D), even after intensity ratings across modalities were carefully matched (all Pearson's $r < 0.140$, $p > 0.100$, $BF_{10} < 0.333$, Kendall's tau-b < 0.110, $p > 0.300$, $BF_{10} < 0.333$).

Conclusions

Our study provides compelling evidence that VPs, though not encoding pain sensitivity, do selectively reflect pain discrimination.

Acknowledgement: This work was supported by the National Natural Science Foundation of China (31822025, and 32071061).

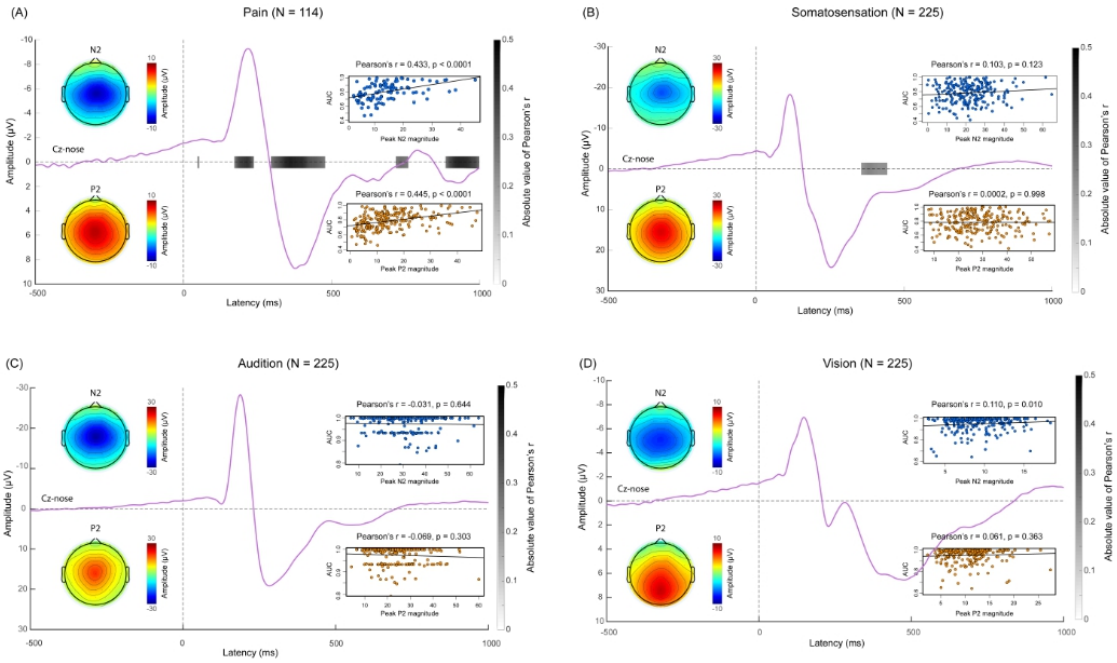


Fig 1. Grand average ERP waveforms in four modalities and between-individual correlations between ERP amplitude and discrimination ability quantified with AUC values. Grey-shaded areas denote time points at which the amplitude significantly correlated with AUC values after FDR correction.

不愉悦气味对年轻男性警觉注意的影响:来自行为与 ERP 的证据

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目的

对不愉悦气味的注意对个体的生存有着至关重要的作用，因为它们可能代表着危险的信号。然而，气味浓度在其中是否起到作用仍存在争议。在本研究中，我们探索了两种浓度的愉悦与不愉悦气味对注意网络（警觉网络、定向网络和执行控制网络）的作用。

方法

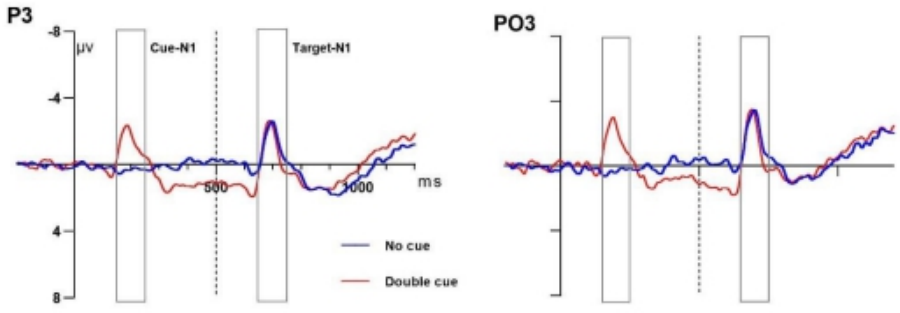
对 30 名年轻男性（平均年龄为 23.12±2.3 岁）采用注意网络测试（Attention Network Test，ANT）检测行为反应，同时通过评估 N1 和 N2 成分波幅检测电生理反应。

结果与讨论

我们发现，气味浓度对注意网络不存在影响。不愉悦的气味在警觉和执行控制网络中诱发了更大的线索相关的 N1 和 N2 波幅；然而，行为反应时间只在警觉网络中表现出减少的趋势。

结论

我们的研究没有提供气味浓度效应的支持性证据。但我们的研究确实表明，更多的注意力资源被分配到警觉相关的刺激上，以提升年轻男性对潜在威胁的行为反应。



不愉悦气味条件下警觉网络在电极点 P3 以及 PO3 的总平均 ERP 线索波幅差异。无线索（蓝色线）、双线索（红色线）；线索起始时间为 0 毫秒（实线），目标起始时间为 500 毫秒（虚线）。

EEG research on the performance of tracking multiple objects in ice-hockey athletes

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Objective

In many sports, visual attention plays a crucial role. For example, ice-hockey athletes need to pay attention to and continuously track the position of the ball, teammates and opponents, to obtain comprehensive information on the field. The ability to track multiple objects (MOT) in a dynamic scene is a prerequisite for ice-hockey athletes to make decisions. Most of the research results showed that athletes perform better in the MOT task, but the conclusion is still controversial. Whether the attention load will affect the athlete's tracking advantage needs to be further explored. In addition, when completing the MOT tasks that require attention resources, the athlete' neural oscillations characteristics still need to be determined. Therefore, in the current study, the behavioral measurement and EEG technique were used in the task of MOT to explore the performance of tracking multiple objects and the characteristics of neural oscillations in ice-hockey athletes.

Methods

A mixed design of 3 (group: expert group, novice group, control group) ×3 (speed: slow speed, medium speed, fast speed) was adopted in experiment 1.The tracking performance and neural oscillations of ice-hockey athletes were investigated under different attentional loads by changing speed in the MOT task. The tracking accuracy and the power of high alpha nerual oscillation were recorded and analyzed.

Results

The tracking accuracy of participants decreased significantly with the acceleration of speed in the experiment 1. The tracking accuracy of ice-hockey athletes is significantly higher than that of control group under the medium speed condition. The tracking accuracy of the expert group was significantly better than that of the control group under the fast speed condition. The power of high alpha nerual oscillation of participants decreased significantly with the acceleration of speed. The power of high alpha nerual oscillation of ice-hockey athletes is significantly lower than that of control group under the medium speed condition. The power of high alpha nerual oscillation of the expert group was significantly better than that of the control group under the fast speed condition.

Conclusion

The performance of tracking multiple objects decreases, and the event related desynchronization of high alpha rhythm increases as the attentional load accelerates. (2) With the acceleration of speed, ice-hockey athletes showed the superiority of tracking performance and lower high alpha rhythm desynchronization. The higher the athletic skill level, the greater the effect.

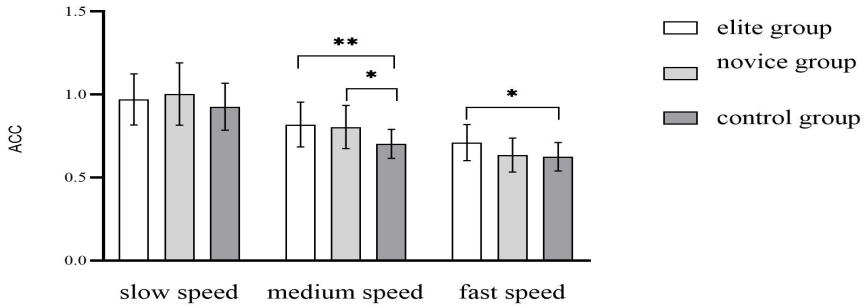


Figure1. Tracking performance of three groups.

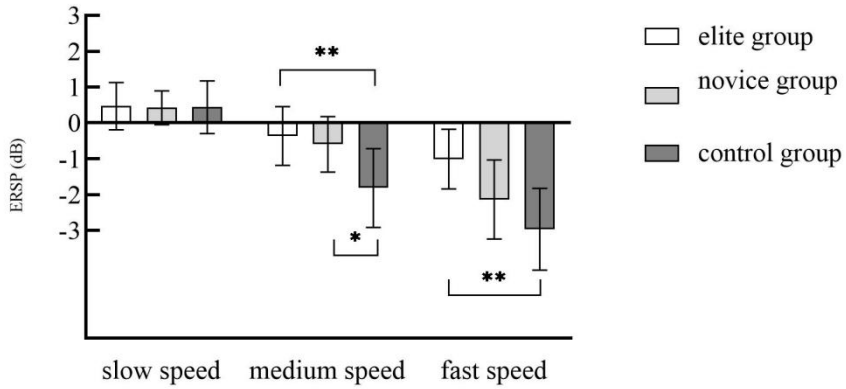


Figure2. Power of high alpha rhythm in three groups.

负面评价恐惧的认知神经机制：基于对社会评价效价和情境的加工

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目的和假设

个体会恐惧/忧虑负面评价，且经过长期的社会化，形成不同程度的稳定的特质倾向，即负面评价恐惧（Fear of negative evaluation, FNE）。为考察FNE是否影响及如何影响个体对社会评价信息（如情境和结果内容）的加工，该过程的认知神经机制具有怎样的一般性和特殊性，我们综合改编社会网络攻击范式（Achterberg et al., 2016; Schindler et al., 2014），对于FNE加工内容效价和情境的一般性，假设额顶中部与注意相关的脑电成分（N1和P2）和对奖赏敏感的P3对评价效价和情境敏感（假设一）。对于FNE加工社会评价信息的特殊性，提出两个探索性假设。假设二，高低FNE对评价情境的敏感性有差异，会调节脑电成分的情境效应；假设三，高低FNE对内容效价的敏感性有差异，会调节脑电成分的效价效应。

方法

从250名完成中文版简版负面评价恐惧量表 (brief fear of negative evaluation, BFNE, Leary, 1983)的被试中选取高低FNE被试参加脑电实验。其中高FNE者 (hFNE) 18人，低FNE者 (lFNE) 20人，均完成社会网络评价任务。被试作为受评者观看两种情境下的积极和消极反馈：人反馈(社会情境)和电脑随机反馈(非社会情境)；反馈用手势符号，拇指向上表示喜欢，向下表示不喜欢。含8组280个试次，共4种实验条件。数据分析主要采用2 (组别：hFNE, lFNE) × 2 (评价来源：人，电脑) × 2 (内容效价：喜欢，不喜欢) 的重复测量ANOVAs。

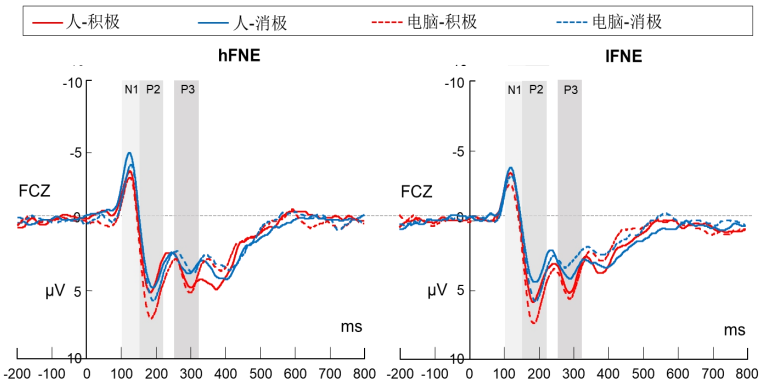
结果和讨论

加工含情境和效价信息社会评价反馈的一般性：额顶中部的早期成分N1和P2均对情境和效价敏感，社会性情境和消极评价引起更大的N1和更小的P2；P3对效价敏感，积极反馈引起的P3更强，证明假设一。高低FNE者加工社会评价反馈的特殊性：在电极点FCz和CPz处发现高低FNE与效价的交互效应，消极评价比积极评价引起hFNE更强的N1，lFNE的N1对效价不敏感，即证明假设三高低FNE会调节注意警觉的效价效应；未发现FNE对晚期奖赏加工(P3)的影响。这些结果表明FNE可能仅调节对消极社会评价内容的早期注意警觉，这与常以FNE作为指标的社交焦虑的研究结果不太一致。高FNE中既有高社交焦虑者也有低社交焦虑者，FNE是社交焦虑症状的必要非充分条件，未来需开展区分FNE和社交焦虑的细化研究。

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Effects of Retrieval-Extinction Training on Internet Gaming Disorder

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Objective

The effect of memory retrieval-extinction manipulation on substance use disorder intervention has been validated, and we try to apply this manipulation to the intervention of Internet gaming disorder (IGD), aiming to explore whether the individuals' craving for Internet games can decrease after they receive the memory retrieval-extinction training within memory reconsolidation window.
And the impact of memory retrieval-extinction manipulation on cognitive function, such as reward processing also need to be studied.

Methods

We recruited 60 participants during the experiment. All participants received baseline assessments of demographic and clinical characteristics, cue-induced gaming craving score, Monetary Incentive Delay Task (MIDT) with EEG recording one day 1, one day 2-3 they divided into two groups randomly and trained by retrieval-6h-extinction (R-6h-E group) manipulation or retrieval-10min-extinction (R-10min-E group) manipulation for two days; On day 4, all participants underwent the experiment procedure identical to that used on day 1. And in the follow-up test on days 34 and 94, participants' craving level were tested.

Results & Discussion

R-10min-E training significantly reduced IGD individuals' gaming craving. Moreover, the R-10min-E training also recovered monetary reward processing of IGD individuals which corroborated by assessment of gain cues in the MIDT, such as faster response, higher P3 amplitude, and stronger fronto-parietal function connectivity to monetary reward cues.

Conclusion

We applied the R-10min-E training to the treatment of IGD for the first time. The two days R-10min-E training reduced addicts' craving for Internet games, recovered monetary reward processing of IGD individuals, and maintained long-term efficacy. These results suggest that retrieval-extinction manipulation may have great potential to be utilized for clinical use to treat IGD.

Acknowledgement: This work was supported by the 100 Talents Programme of the Chinese Academy of Sciences (BJ2070000047), National Natural Science Foundation of China (31230032, 31171083, 31471071) and Natural Science Foundation of Anhui (1208085MH1).

Impaired Alpha Rhythm in Bad Sleeper during Nap: A High-density EEG Study

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Objective

A wealth of sleep studies based on electroencephalogram (EEG) have found that poor sleep quality has decreased alpha rhythm during night sleep. Whether the EEG rhythm during a middle-noon nap has a similar pattern is still a lack of research. At present, there are relatively few studies on the relationship among sleep quality, nap macrostructure, and electrophysiological characteristics. Therefore, the high-density EEG was used to explore the relationship between sleep quality and brain activity in our current study. The research is of great guiding significance to the development of the electrical neural stimulation therapy to improve sleep quality, especially for the stimuli regions for selection and the time window for implementation.

Methods

The research recruited 37 healthy college students from Southwest University in Chongqing (male: 17; female: 20). The subjects arrived at the laboratory at 11:30 am to fill in the overall scale of the experiment, including the SRSS, PSQI, and SDS. After a 20-minute break, the subjects filled out the pre-experiment test questionnaire, including SSS and PANAS. Around 1 pm, the subjects hooked up their brain electronics and took a nap. About 90 minutes later, the experimenter waked up the subjects and instructed them to fill in the post-experiment questionnaire, SSS, and PANAS, i.e., the same content as the previous questionnaire.

Results & Discussion

After the analysis of PANAS scores before and after napping, it was found that the degree of negative emotion of subjects decreased significantly after napping, while the degree of positive emotion increased correspondingly. Correlation analysis of the score of SRSS and PSQI revealed a highly positive correlation, indicating that the SRSS score is a useful index for the quality of sleep. After the correlation analysis of SRSS and SDS scores, we found that the two were significantly positively correlated with a highly significant value. After analyzing the subjects' sleep quality (SRSS and PSQI) and sleep parameters derived from EEG, it was found that the subjects' sleep quality was not significantly correlated with the length of nap, the proportion of deep sleep, or the number of special EEG wave in each sleep period. However, by calculating the EEG spectra of each sleep period, we found that sleep quality is mainly negatively correlated with the alpha rhythm energy of the occipital lobe. Interestingly, a strong negative correlation exists in all N1, N2, N3 sleep stages and the waking period, especially during the N2 period.

Conclusions

(1) Sleep quality directly affects the emotional state of the subjects; (2)Sleep quality (SRSS) is mainly negatively correlated with the alpha rhythm energy of the frontal and occipital lobe; (3)During the N2 sleep period, sleep quality is highly correlated with alpha rhythm, and subjects with poor sleep quality also have lower alpha rhythm, which may reflect the parameter of fewer spindle waves in the occipital lobe. We believe that the enhancement of power of alpha rhythm by neural stimulation or other methods in the N2 phase can effectively improve the sleep quality of subjects. This conjecture needs to be verified by more long-term research and exploration in the future.

Acknowledgement: This work was supported by the National Science Foundation of China (grant number 31971028), and Major Project of Medicine Science and Technology of PLA (AWS17J012).

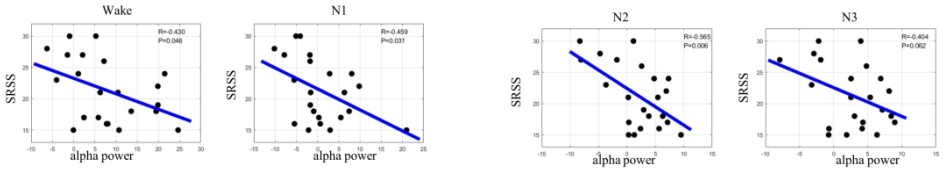


Figure 4: The correlation between occipital lobe alpha rhythm energy and sleep quality under different wake-sleep conditions

ERPs reveal the time course of knowledge integration

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Objective

Building a knowledge base is one of the most important tasks in development. New content can be entered into semantic memory not only through direct experience (e.g., explicit instruction, observation), but also through self-generation resulting from a number of logical processes, including deduction, induction, and analogy. Another means of extension of semantic memory is self-generation of new knowledge through integration of information acquired in two (or more) separate but related learning episodes. Previous studies mainly investigated knowledge extended through integration remains accessible after delay, little is known about the time course over which newly self-derived information through integration and the effects of prior knowledge on undergraduate students' self-generation newly knowledge through integration. The present study aimed to examine the time course of self-generated through integration of separate but related facts pair by using the event-related potentials (ERPs). Considering the role of prior knowledge experience, this study distinguishes knowledge integration into instant integration and delayed integration.

Methods

20 right-handed students were recruited as paid volunteers from a university. At the encoding phase, Participants read each of 180 sentences presented on a computer, and then judged when the facts in the sentences should be learned: primary school, middle school, or college. After a break of 5 minutes, they were tested the new information by integrating the stem facts learned during encoding phase. ERPs were collected as subjects read each of 100 sentences. To permit observation of anticipated changes over time in the neural status of the self-derived information, each sentence was presented twice.

Results & Discussion

Behavioral results showed that a significant main effect of the number of presentations. The average reaction time of all fact types on the second presentation is significantly faster than the first presentation. Reaction times of the fact type also found faster in response to well-known facts than instant integration, delayed integration and novel facts. And the results of ERP showed that the N400 responses to integration facts differed from responses to transitive reasoning facts and novel facts,

and did not differ from responses to well-known facts, suggesting that the self-derived newly information through integration occurs quickly and the integrated fact had been incorporated into the semantic knowledge base. In addition, according to the analysis of time course, the amplitude of the delayed integration facts decreased and moved closer to well-known facts in the 350ms during the second presentation, indicating that the delayed integration had been occurred by combining the stem facts and the new factual knowledge quickly transited to known. Comparing the two presentations revealed that knowledge experience affected the time course of integration. Delayed integration occurred later than instant integration, as it needs to activate relevant information in long-term memory.

Conclusions

The time course of self-generated new knowledge through integration of separate but related facts pair and the prior knowledge experience does affect the time course of integration. These findings help explain the richness of semantic memory and also further our understanding of the basic cognitive processes involved in extension of knowledge.

Emerged human-like performance of expression representation in a deep convolutional neural network

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Objective

Face identity and expression play critical roles in social communication. Despite the accumulating neural evidence that suggests separate pathways for facial identity and expression recognitions, since the visual input of face stimuli is shared, there is a heated debate regarding how and at what stages the processing of facial expression and identity would separate. Recent research found that the deep convolutional neural network (DCNN) trained to recognize facial identities spontaneously learn features that support facial expression recognition, and vice versa, suggesting an integrated representation of facial identity and expression. Here, we explored the extent to which the retained representation of facial expression in the DCNN is similar to that in human perception, and importantly, whether the emergence of expression-selective units is attributed to either face-specific experience or domain-general processing.

Methods & Results

We first explored whether expression-selective units could spontaneously emerge in a DCNN pre-trained for facial identity recognition. The well-known expression confusion effect and categorical perception effect was adopted as the measures to examine whether these expression-selective units exhibited the human-like expression perception. Consistent with previous findings, we found that the expression-selective units spontaneously emerged in a VGG-Face trained for facial identity recognition, and tuned to distinct basic expressions. Importantly, they exhibited typical hallmarks of human expression perception, i.e., the facial expression confusion effect and categorical perception effect.

Then, we investigated whether the emergence of expression-selective units is attributed to either face-specific experience or domain-general processing, by carried out the same analysis on a VGG-16 but trained for object classification, and an untrained VGG-Face without any visual experience, both of them having the identical architecture with the pre-trained VGG-Face. Similar expression-selective units were found in both DCNNs, however, they did not exhibit reliable human-like characteristics of facial expression perception.

Conclusions

Taken together, our computational findings revealed the necessity of domain-specific visual experience of face identity for the development of facial expression perception, highlighting the contribution of nurture to form human-like facial expression perception. In addition, symbol manipulation can hardly explain our results. Beyond the weak equivalence between human and DCNNs at the input-output behavior, emerging simulated algorithms between models and humans could be established through domain-specific experience.

Acknowledgement

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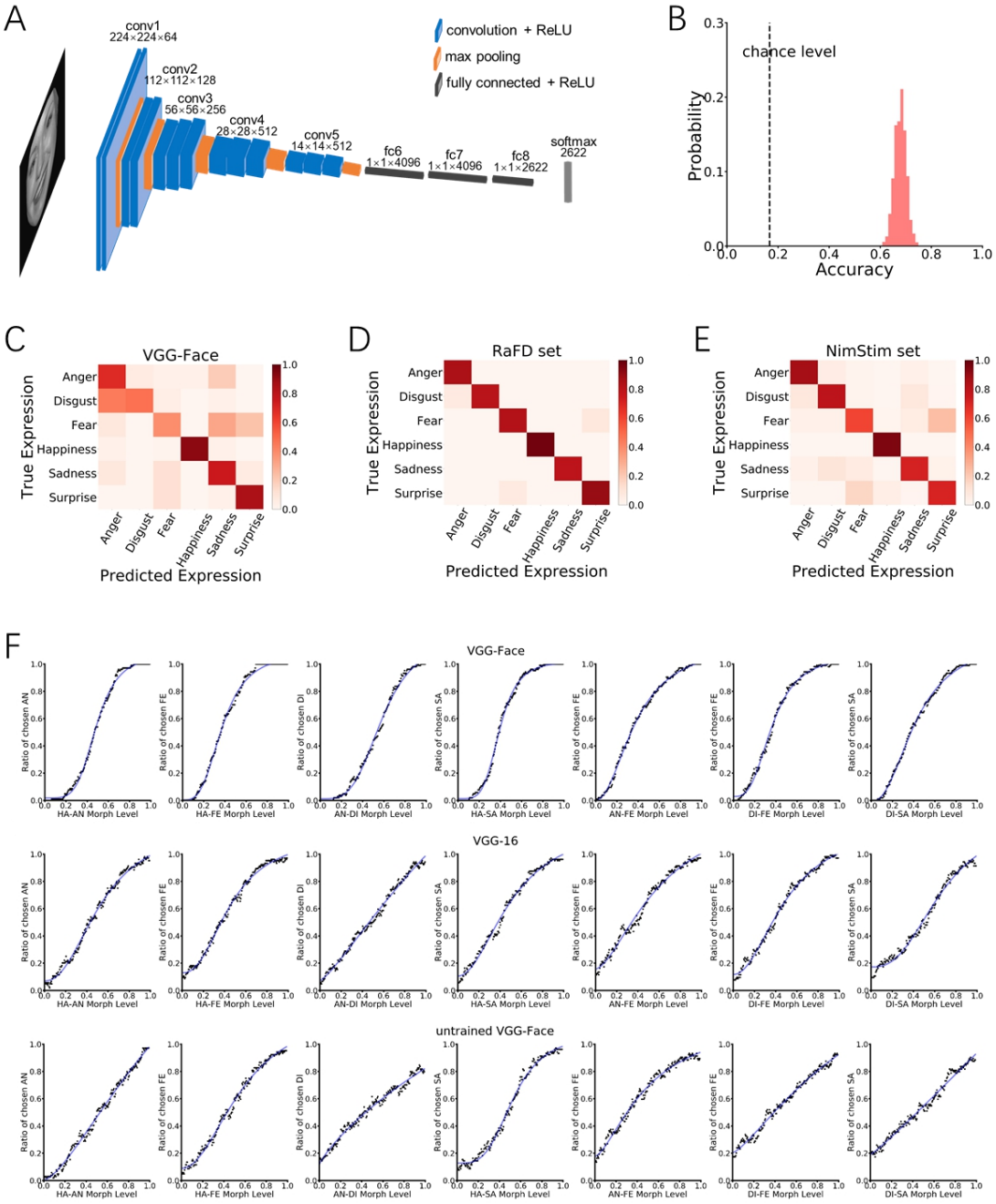


Figure 1. (A) The architecture of the VGG-Face. (B) The expression discriminability of the expression-selective units emerged in the VGG-Face for the RaFD. (C) The confusion matrix of the units for the RaFD. (D) Human confusion matrix for the RaFD (Adapted from Langner et al. 2010). (E) Human confusion matrix for the NimStim set (Adapted from Tottenham et al. 2009). (F) The identification rates for the morph seven continua. These rates show the identification frequency of one out of the two expressions. Black dots represent true identification rates. Blue solid lines indicate fitting for the logistic function.