·心理学·

The Brain Volume of NAcc Might Predict Individual Financial Risk Preference*

LU Qi-lin[1], TANG Yi-yuan[1,2△]

(1 Institute of Neuroinformatics, Dalian University of Technology, Dalian, China, 116024;

2 Department of Psychology, University of Oregon, Eugene, OR, USA, 97403)

ABSTRACT: Both mammal neurochemical and human imaging studies suggested that the nucleus accumbens (NAcc) could affect risk preference by expecting risk benefits. However, few studies addressed the relationship between individual financial risk preference and the NAcc structure in the brain. In this study, the contribution of the NAcc volume and individual financial risk preference was examined by the domain specific risk taking scale and FIRST imaging tool (FMRIB's integrated registration and segmentation tool). The result suggested that the volume of NAcc may underlie human financial risk preference traits.

Key words: NAcc; MRI; Financial risk preference

Chinese Library Classification(CLC): R Document code: A

Article ID:1673-6273(2012)01-129-03

Introduction

Lots of studies implicated that the nucleus accumbens (NAcc) is relevant to reward expectation. Mammal neurochemical and electrophysiological studies found that dopamine release occurred more robustly in the NAcc during reward expectation than reward presentation [1-3]. Human functional MRI (fMRI) studies also showed that this region activated when participants expected rewards. For example, a monetary reward and punishment experiment found that NAcc could code for the expected positive incentive [4]. Another study observed both monetary and social reward expectation would activate the NAcc [5].

Likewise, a widely observed phenomenon in risk-based decision making is that the risk preference could be influenced by its accompanying reward expectation. The psychological risk-return framework proposed that one's preference for risky options is a trade-off between the expected rewards and the perceptible riskiness [6,7].

Thus, it was not surprising that the NAcc has much to do with risk preference. Neurological studies suggested that the brain regions, which were recruited by reward processing, also played an important role in the risk-based decision-making [8-10]. Cardianl and Howes found the NAcc-lesioned rats revealed a risk-averse pattern of choice behavior [8], whereas the ones with intact NAcc function biased the choice toward large potential rewards, even though this behavior would bring a greater risk [10]. The NAcc also took part in the human risk-based decision making process. For example, one fMRI study showed bilateral NAcc were more activated when selecting large gain than selecting small option for the higher expected rewards [11]. Moreover, another study examined the investors' systematical errors when they made financial decisions. The results showed the activation of NAcc could lead to a risk-seeking mistake which participants overestimated the profit of the investment, whereas the activation of insula might result in a risk-aversion mistake which was caused by underestimating the profit of the investment [12].

Although previous research focused on the NAcc role in the reward expectation and its influence on risk-based preferences, to our knowledge, no prior work addressed whether different volume of NAcc would cause different individual financial risk preferences by affecting the expectation of financial rewards.

In recent years, the development of advanced brain imaging technology made it possible to explore the relationship between personality and structure of specific brain regions. For example, the greater temporal cortical gray matter volumes implied the higher self-transcendence [13], the larger brain volume implied the lower neuroticism [14], the lower supplementary motor area gray matter volume density implied the weaker self-control [15]. As a stable personality trait [6,16], some studies have already investigated the relationship between brain structure and attitude to reward expectation [17-19]. However, most of these studies did not distinguish the different domains of reward expectation attitude and did not extend their results to the individual risk preference which was closely related the individual reward expectation attitude.

Reward expectation attitude and risk preference were different in specific domain. Slovic et al. proposed "one can expect to find differences in the perception of risks and benefits in these different domains of decisions because decisions in these domains score differently on the psychological risk dimensions" [6,20].

In the present study, we hypothesized tha t the volume of NAcc would predict individual financial risk preference indirectly by influencing reward expectation.

*Foundation Itsms: This study was supported by a grant from the Natural Science Foundation of China (60971096) and Templeton Foundation.

The authors appreciated the suggestions from Qingbao Yu and Guangheng Dong

E-mail: yy2100@126.com; Tel :+86-0411-84706046

(Received:2011-04-23 Accepted:2011-05-18)

1 Method

1.1 Participants

Sixteen undergraduate students from University of Oregon participated in this study (8 female and 8 male, right-handed, mean age ± SD=21.5 ± 1.71). All subjects provided informed consent, consistent with IRB guidelines, and were free of any neurological or psychological disorder.

Their attitude of financial risk preference and its accompanying reward expectation were measured by the DOSPERT (The Domain Specific Risk-Taking Scale) scale [7], which is a psychometric tool used to measure domain specific risk preference and the expected benefits.

1.2 MRI data acquisition

MR imaging was performed on a Siemens Allegra 3.0 Tesla scanner (Siemens Sonata, Erlangen, Germany). The high-resolution T1-weighted image was acquired in each participant (TR=2500, TE=4.38, Slice Thickness= 1, flip angle = 8°).

1.3 Data analysis

Two subjects' data were excluded from analysis for the structure images or questionnaire missing reasons.

All MR data processing occurred with FIRST (FMRIB's Integrated Registration and Segmentation Tool http://www.fmrib.ox.ac.uk/fsl/first/index.html), which is a semiautomated model-based subcortical segmentation tool under the Bayesian framework. This method carried out a two-stage affine registration to the MNI152 standard space with 1 mm resolution using 12 degrees of freedom and a subcortical mask to exclude voxels outside the subcortical regions. Then, the left and right NAcc were segmented based on shape models and voxel intensities. Finally a boundary correction took place to verify whether the boundary voxels belong to the structure based on a statistical probability. Previous studies have successfully used this technique to acquire the volume of putamen and thalamus in Alzheimer's disease patients [21].

SPSS 16.0 was used to do statistical analysis of NAcc volume, financial preference and expected financial rewards. Normality was tested by Kolmogorov-Smirnov method to determine appropriateness of statistical methods. Pearson correlations were used to examine the relationship between variables. Finally, regression models were used to assess the contribution of NAcc volume in predicting expectation of risk benefit and risk preference.

2 Results

The results of Kolmogorov-Smirnov test showed that all variables followed the normal distributions. The reward expectation revealed significant correlations with the volume of NAcc (Pearson correlation coefficient=0.731, P=0.003) and the risk preference (Pearson correlation coefficient=0.666, P=0.009), whereas the correlation between the volume of NAcc and risk preference was not significant (Pearson Correlation coefficient=0.495, P=0.072).

To obtain the contribution of the NAcc volume in predicting the risk preference, the regression model was applied. As shown in Figure 1, there was a direct contribution from the volume of NAcc to the reward expectation and from the reward expectation to the risk preference. The volume of NAcc and the risk preference could be connected with the reward expectation by an indirect path with the path coefficient 0.731*0.666=0.486.

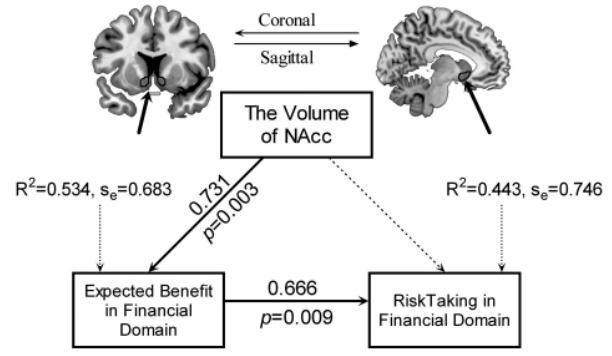

Fig.1 The relationships among volume of NACC, reward expectation and risk preference

3 Discussion

To our knowledge, this is the first study demonstrating the volume of NAcc could predict financial risk preference with mediation by the attitude of financial reward expectation.

The DOSPERT scale was applied to obtain individual attitude of financial risk preference and financial reward expectation. Thus, this study avoided the problems of previous studies which mixed diverse domains of reward attitudes together, and expanded the results to individual risk preference.

The present results were compatible with many previous studies about the relationship between the structure of NAcc and reward attitude. For instant, Lebreton et al. found that the social reward dependence had a positive correlation with the gray matter density of basis ganglia [17] and the results of Cohen et al. suggested the different strengths of limbic-striatal fibers could predict individual differences in novelty seeking [19]. However, another study obtained a different result that a reduced volume in the striatum might be associated with enhanced reward sensitivity measured by the sensitivity to reward scale [18]. Considering the risk preferences and the benefit expectations were specialized into different domains, our results might be more robust in financial domain.

Some limitations to this work should be considered. The latent variables were not used to represent variables to remove the measurement errors for the limited number of MR participants in the present study. The perception of riskiness, which is another independent variable in risk-return framework, was not examined for the methodology reasons of the FMRIB's integrated registration and segmentation tool. This tool could not segment the cortex regions, including anterior medial prefrontal cortex, ventral anterior cingulate and posterior cingulate, which was relating to perceiving riskiness [22].

4 Conclusion

Our results indicated the volume of NAcc could indirectly contribute to financial risk preference by affecting the financial reward expectation.

Reference

[1] Berridge KC, Robinson TE. What is the role of dopamine in reward: hedonic impact, reward learning, or incentive salience?[J]. Brain Res Rev, 1998, 28: 309-369

[2] Ikemoto S, Panksepp J. The role of nucleus accumbens dopamine in motivated behavior: a unifying interpretation with special reference to reward-seeking[J]. Brain Res Rev, 1999, 31: 6-41

[3] Schultz W, Apicella P, Scarnati E, Ljungberg T. Neuronal-Activity in Monkey Ventral Striatum Related to the Expectation of Reward [J]. J Neurosci, 1992, 12: 4595-4610

[4] Knutson B, Adams CM, Fong GW, Hommer D. Anticipation of increasing monetary reward selectively recruits nucleus accumbens[J]. J Neurosci ,2001, 21: art. no.-RC159

[5] Rademacher L, Krach S, Kohls G, Irmak A, Grunder G, Spreckelmeyer KN. Dissociation of neural networks for anticipation and consumption of monetary and social rewards [J]. Neuroimage, 2010,49: 3276-3285

[6] Blais AR, Weber EU. A Domain-Specific Risk-Taking (DOSPERT) scale for adult populations[J]. Judgment and Decision Making Journal, 2006, 1: 33-47

[7] Weber EU, Blais AR, Betz NE. A domain-specific risk-attitude scale: Measuring risk perceptions and risk behaviors [J]. Journal of Behavioral Decision Making, 2002, 15: 263

[8] Cardinal RN, Howes NJ. Effects of lesions of the nucleus accumbens core on choice between small certain rewards and large uncertain rewards in rats[J]. BMC Neuroscience, 2005, 6: 37

[9] Cohen MX, Axmacher N, Lenartz D, Elger CE, Sturm V, Schlaepfer TE. Neuroelectric Signatures of Reward Learning and Decision-Making in the Human Nucleus Accumbens[J]. Neuropsychopharmacology, 2009, 34: 1649-1658

[10] Floresco SB, Onge JRS, Ghods-Sharifi S, Winstanley CA. Cortico-limbic-striatal circuits subserving different forms of cost-benefit decision making,. Cogn Affect Behav Ne, 2008, 8: 375-389

[11] Ino T, Nakai R, Azuma T, Kimura T, Fukuyama H. Differential activation of the striatum for decision making and outcomes in a monetary task with gain and loss[J]. Cortex,2010, 46: 2-14

[12] Kuhnen CM, Knutson B. The neural basis of financial risk taking[J]. Neuron, 2005, 47: 763-770

[13] Kaasinen V, Maguire RP, Kurki T, Bruck A, Rinne JO. Mapping brain structure and personality in late adulthood [J]. Neuroimage, 2005, 24: 315-322

[14] Knutson B, Momenan R, Rawlings RR, Fong GW, Hommer D. Negative association of neuroticism with brain volume ratio in healthy humans[J]. Biol Psychiat, 2001, 50: 685-690

[15] Matsui M, Yoneyama E, Sumiyoshi T, Noguchi K, Nohara S, Suzuki M, et al. Lack of self-control as assessed by a personality inventory is related to reduced volume of supplementary motor area[J]. Psychiatry Research-Neuroimaging, 2002, 116: 53-61

[16] Weber EU. Who's afraid of a little risk? New evidence for general risk aversion In: J. Shanteau BAM, and D. Schum (ed). Decision Research from Bayesian Approaches to Normative Systems: Reflections on the Contributions of Ward Edwards [M]. Norwell, MA: Kluwer Academic Press, 1998

[17] Lebreton M, Barnes A, Miettunen J, Peltonen L, Ridler K, Veijola J et al. The brain structural disposition to social interaction [J]. European Journal of Neuroscience, 2009, 29: 2247-2252

[18] Barros-Loscertales A, Meseguer V, Sanjuan A, Belloch V, Parcet MA, Torrubia R, et al. Striatum gray matter reduction in males with an overactive behavioral activation system [J]. Eur J Neurosci, 2006, 24: 2071-2074

[19] Cohen MX, Schoene-Bake JC, Elger CE, Weber B. Connectivity-based segregation of the human striatum predicts personality characteristics[J]. Nature Neuroscience, 2009, 12: 32-34

[20] Slovic P, Fischhoff, B., & Lichtenstein, S. The psychometric study of risk perception[M]. In: V. T. Covello JM, & J. Mumpower (ed). Risk evaluation and management. New York: Plenum; 1986. pp. 3-24

[21] De Jong LW, van der Hiele K, Veer IM, Houwing JJ, Westendorp RG, Bollen EL, et al. Strongly reduced volumes of putamen and thalamus in Alzheimer's disease: an MRI study [J]. Brain, 2008, 131: 3277-3285

[22] Qin JG, Han S. Parsing Neural Mechanisms of Social and Physical Risk Identifications[J]. Human Brain Mapping, 2009, 30: 1338-1351

大脑伏隔核体积可能预测个人金融风险偏好 *

鹿麒麟[1] 唐一源[1,2△]

(1 大连理工大学,神经信息研究所 辽宁 大连 116024 ;2 俄勒冈大学,心理系 美国 俄勒冈 97403)

摘要:以往的研究发现:大脑伏隔核参与了期望收益的判断过程,继而影响了风险决策。但目前还没有研究表明,伏隔核结构是否与个体的其风险偏好有关。本研究通过使用"特定领域风险量表"以及"FIRST"软件包来研究:个体伏隔核体积差异是否可以导致不同的风险偏好。试验结果表明,伏隔核体积对个体金融风险偏好有一定贡献。

关键词:伏隔核,磁共振成像,金融风险偏好

中图分类号:B84 **文献标识码**:A **文章编号**:1673-6273(2012)01-129-03

* 基金项目:国家自然科学基金资助:60971096

△通讯作者:唐一源,大连理工大学神经信息学研究所所长、教授、博士导师,主要从事脑功能成像、身心相互作用、神经信息学等研究

E-mail: yy2100@126.com; Tel:+86-0411-84706046

(收稿日期:2011-05-23 接受日期:2011-06-18)