Chronic Back Pain Patients Show Differences in Behavior and Brain Activity During a Loss-Aversion Gambling Task

3352
OHBM 2013

Sara E. Berger[1], Alexis T. Baria[1], Marwan N. Baliki[1], Ali Mansour[1], Elle L. Parks[1], A.Vania Apkarian[1,2] *

[1]Department of Physiology, [2]Departments of Anesthesia and Surgery, Feinberg School of Medicine, Northwestern University, Chicago, IL

INTRODUCTION

- Recent research from our lab has shown various changes in the reward circuitry (in particular, connections to/from the nucleus accumbens (NAc)) of individuals with chronic back pain. Additionally, many labs have observed that people with a variety of chronic pain conditions perform differently (most often poorly) in tasks designed to engage reward-valuation, motivation, and decision-making systems. It is still unknown, however, how the presence of pain influences reward processing and vice versa, and this is true for both local and global network questions.

- Given this, we are interested in exploring the link between pain and reward perception, particularly in the context of people who endure long-term pain and suffering.

- In the present study, we compare performance scores for a monetary gambling task – behavioral loss aversion – between healthy pain-free controls and individuals with chronic back pain. We then correlate these scores to participants' resting state data obtained on the same day to investigate whether any differences we see in performance are related to differences in each group's baseline functional connectivity, with special interest in the NAc.

METHODS

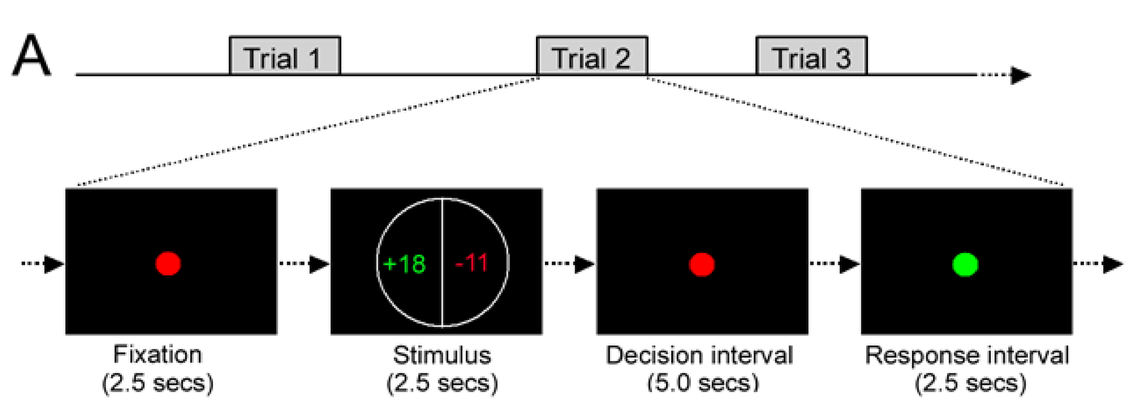
- 18 healthy controls (HC) and 9 chronic back pain (CBP) patients completed the task and scans (and had usable data) as part of a longitudinal study. All patients were diagnosed by a clinician; CBPs had back pain >1 year with no other pain co-morbidities, and HCs had no history of back pain.

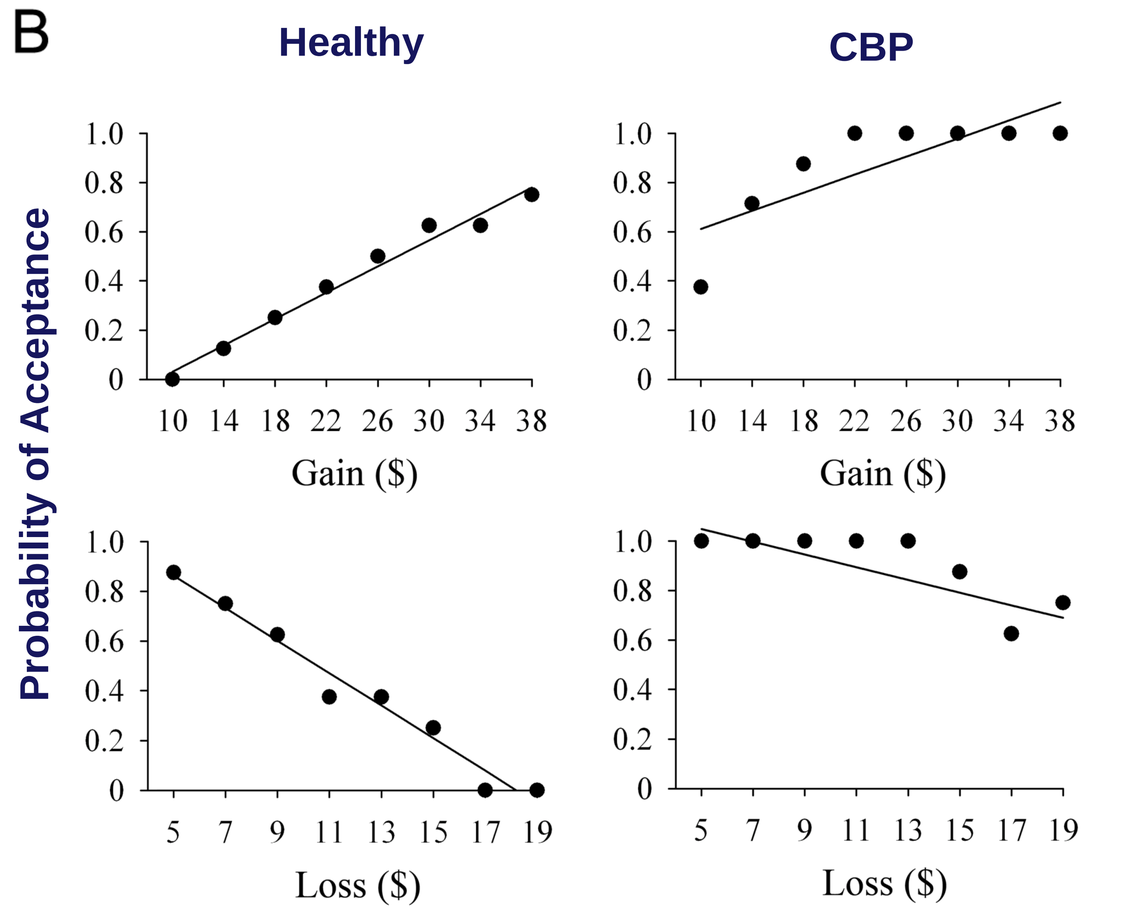
- The task was performed over the course of two fMRI scans of identical length, and the resulting behavioral scores were calculated according to previous reports by Tom et al (2009) (**Figures 1 and 2**). Although differences in performance were seen, GLM analyses modeling the task alone or different aspects of the task (losses versus gains, accepts versus rejects, difficulty of decisions, etc) failed to identify any differences that survived correction for multiple comparisons between the two groups. Therefore, we decided to investigate any potential differences that could account for behavioral scores in an alternative way – via looking at individuals' resting state NAc connectivity, scans of which were collected on the same day as the task.

- Additionally, as the shell and core regions of the NAc exhibit different connectivity and are associated with different functions, we assessed the connectivity of these subdivisions independently and correlated it to gambling behavior to determine whether they play distinct roles in reward processing.

- Resting functional data was registered to 2x2x2 mm standard space and mean BOLD signals from the shell and core, as well as 10 different target ROIs known to be anatomically connected to the NAc, were extracted and their functional connectivity was calculated. Target ROIs were determined using the Harvard-Oxford atlas. Functional connectivity was correlated to behavioral scores for HC and CBP separately and compared (**Figure 3**).

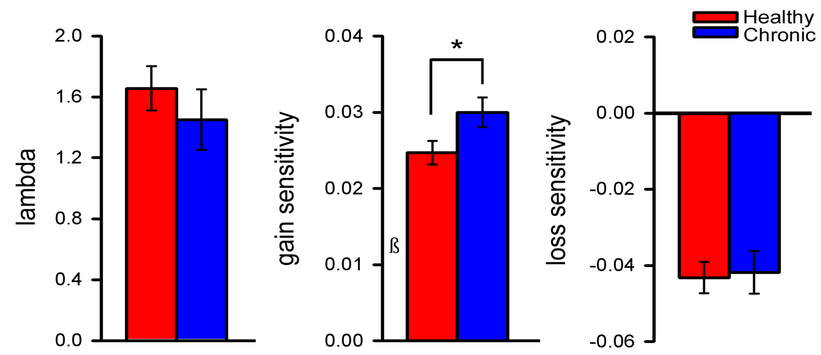
1 Behavioral Loss-Aversion Task: Design and Calculations





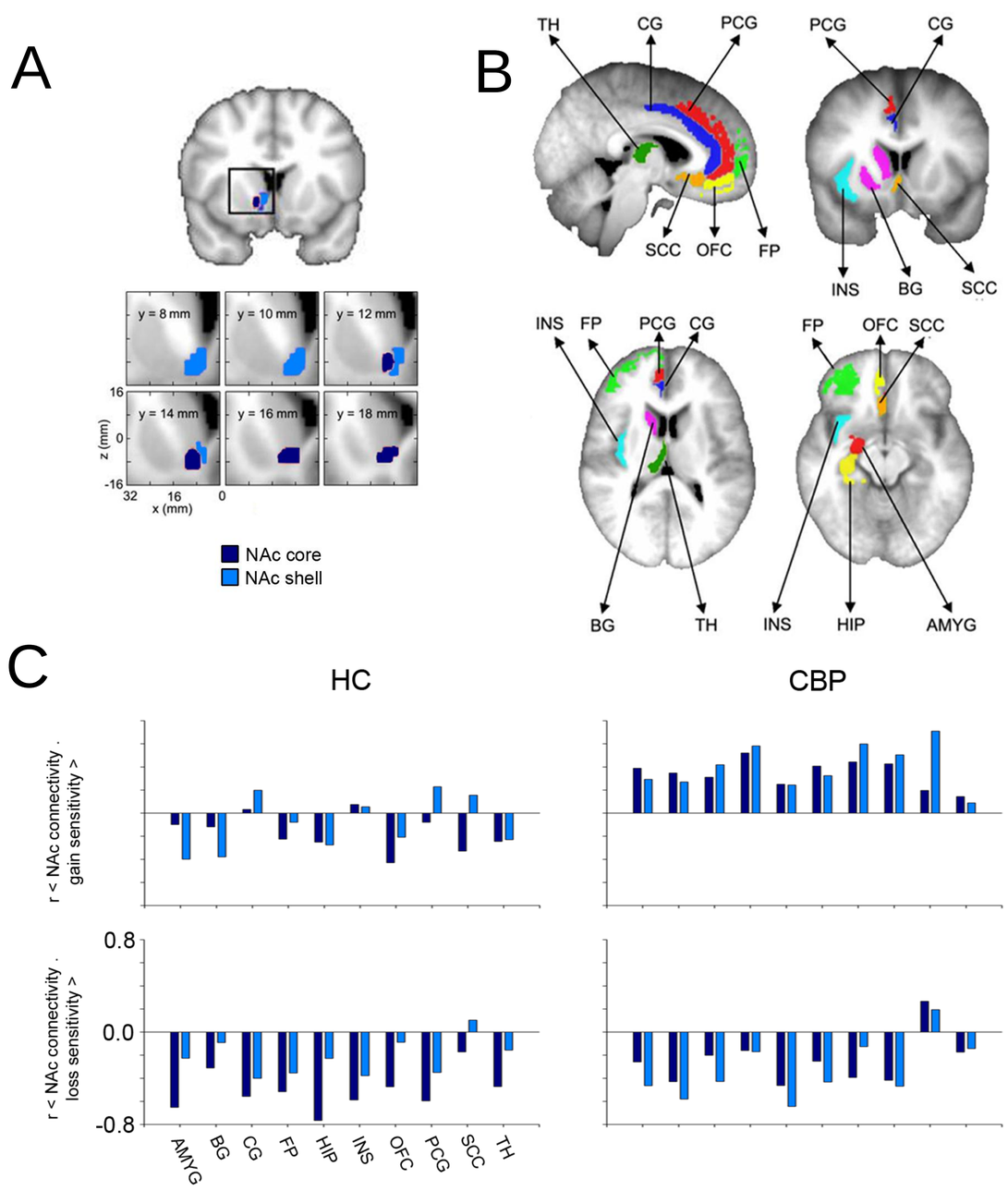
A. The task was performed during an fMRI scan. For each trial, subjects were shown a display depicting an amount of potential gain (green) and potential loss (red), and after a decision period, had to accept or reject the gamble with a computer mouse (with a 50% chance of choices resulting in either outcome). Gains ranged between $10 and $38 (increments of 4) and losses between $5 and $19 (increments of 2). There were 64 trials total divided over two scans. **B.** Regression coefficients for each person's loss and gain sensitivity were computed from these trials, and the log of the ratio of loss/gain equaled their individual level of loss aversion (lambda). An example of one healthy control and one CBP patient is shown. Lambda scores were averaged across groups (see Figure 2).

2 Behavioral Results: CBPs are more gain-sensitive than HCs



After significant difference in behavior between healthy participants and CBP patients was only seen in gain sensitivity scores ($p<0.05$). It should be noted that a factorial analysis revealed a significant interaction between sex and group for lambda and gain scores ($p<0.05$ for both): post-hoc tests showed that CBP males had significantly lower lambda scores and significantly higher gain scores than their healthy counterparts; additionally, male CBPs had significantly higher gain scores than female CBPs (figure not shown).

3 NAc resting state connectivity correlates with behavioral scores



A. We previously subdivided the NAc based off of DTI anatomical connections into putative shell and core regions. **B.** Functional connections from shell and core to regions known to be anatomically connected (shown as colored areas and labeled) to the NAc were determined by calculating the Pearson correlation coefficient between their corresponding mean voxel-wise BOLD signals. **C.** Functional connectivity was then correlated to gain and loss sensitivity across subjects. Notice that while loss sensitivity was negatively correlated to connectivity for both groups, gain sensitivity is notably more positively correlated to connectivity in CBPs, perhaps corresponding to the behavioral differences between groups. No differences in lambda correlation were present (not shown).

CONCLUSIONS

- Our findings suggest that individuals with back pain are more gain sensitive (and in turn, perhaps more likely to act impulsively or take risks), a quality which may impact their decision-making and reward processing on a daily basis.

- We chose to examine the circuitry most commonly identified with reward processing, and we found that CBPs' gain sensitivity was more positively correlated to overall NAc connectivity than the HC group, although both showed overall negative correlations to loss sensitivity.

- Correlation of NAc core and shell connectivity to behavior was marginally different, with the core exhibiting overall stronger negative correlations to loss sensitivity in HC, while more positive correlations to gain sensitivity were seen in the shell for CBP.

- We have shown previously that functional connections in the NAc are altered in chronic pain patients while performing pain-related tasks in the scanner. Although the NAc connectivity during rest is not different between groups here (not shown), how it correlates to behavior is markedly altered in pain patients, suggesting that impulsive behavior related to chronic pain may be less influenced by inhibitive mechanisms acting on reward circuit activity.

Funded by NIH Grants NS035115 and T32 NS047987