A pilot study on a Semicircular pain rating scale

Cocoan Lab Summer Intern: NaEun Oh & Jiewon Kang

COCOAN LAB

Center for Neuroscience Imaging Research

INTRODUCTION

- The forward inference map for "pain" from neurosynth.org [1] and SIIPS1 suggests SMA (including pre-SMA) as regions predictive of pain. However, SMA does not appear in "classic" pain processing regions [2] according to the reverse inference map [1].
- These inconsistencies in motor activation from pain could imply an issue in methodology of pain neuroimaging research, considering that SMA is a brain region known for functions such as motor preparedness and initiation.
- Most pain neuroimaging studies use linear rating scales such as visual analog scale (VAS) **(Fig. 1.b)**. Due to restrictions of this scale subjects undergoing high pain would be required to move a greater distance. Hence, potential motor confounds may exist during these pain rating experiences and could account for the correlation between motor area activation and high pain.
- We developed a **Semicircular rating scale (SemiC)** in attempt to resolve effects of potential motor confounds**.** It is a continuous scale with ratings on the arc between two extremes at endpoints (**Fig. 1.a**). Rating points are at **equal distance** from the center.
- We can also study trajectory each subjects draw to reach final rating as subjects can freely move within the semicircle to select their rating. Rating trajectory recordings could be used to model the effects of uncertainty induced by social cues.

AIMS & HYPOTHESES

- **Hypotheses**
  - ✓ VAS and SemiC will have different patterns of activation in SMA during pain and rating periods
  - ✓ Rating trajectories of SemiC will better reflect different levels of prediction error between social cues and pain stimuli than VAS.
- **Focus of pilot experiment**

  (1) Construct validity of SemiC

  (2) Investigate cue effects on pain ratings using VAS and SemiC

  (3) Compare rating trajectory of VAS and SemiC

METHODS

- The experiment consists of three sessions: (a) movement assessment session, where participants move a rating cursor to a fixed target point, (b) pain rating session, in which participants rate pain stimuli without cues, (c) pain-with-cue session, where participants see a social cue and then rate pain stimuli.
  - Sessions (a) - (c) was conducted inside the MRI scanner for one subject and behavioral experiments for four subjects excluded session (a).
  - Subjects were required to participate on two separate days, each day for a single rating scale type.
- **Social cues** show others' ratings to the exact same pain stimuli. When given these cues before receiving painful stimuli, subjects would anticipate pain intensity based on cues.
- Fictitious cues were created for each subject in order to manipulate levels of uncertainty. Individual pain ratings obtained from session (b) were used to generate mean ratings for each of the three pain intensities. Half the difference between lowest and highest mean intensity (δ) were used to set boundaries for cue intervals of each intensity (**Fig. 2**) Four different standard deviations were used in order to generate 12 types(3*4) of social cues. Cues were randomly selected for corresponding pain intensities.
- We used pressure pain with intensities 4, 5, 6 kg/cm^2.
- Physiological data including Electrocardiogram (ECG), Electrodermal activity (EDA), Respiration (RSP) were recorded with Biopac.

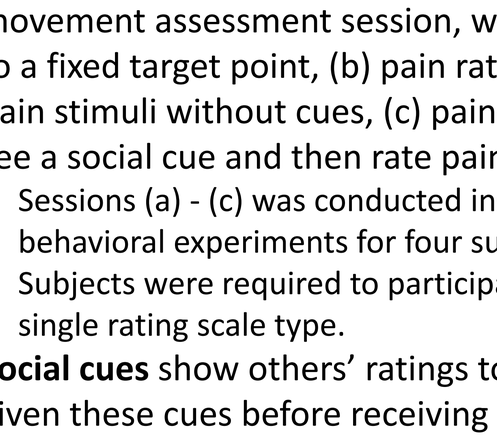

Figure 1.a. Semicircular rating scale(SemiC), **b.** Visual Analog Scale(VAS)

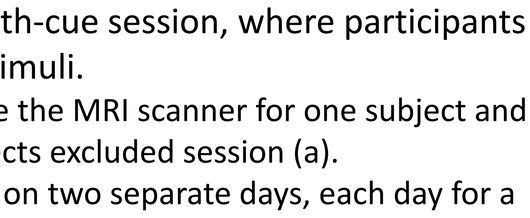

Figure 2. Generating social cues used in the experiment

Additional Information

- SIPPS1: a recent multivariate pattern of fMRI activity that predicts pain above and beyond nociceptive input

RESULTS & ANALYSES

- **Fig 3.** Averages of each subjects' mean intensity rating were higher for SemiC. The relatively increasing trend in ratings depending on pain intensity was not consistent for subjects that had low ratings even for high intensity stimuli.

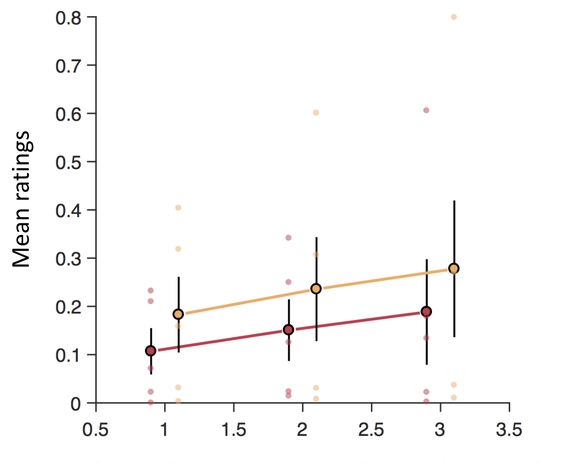

Fig 3. Average of mean intensity ratings between subjects (orange – SemiC, red – VAS)

- **Fig 4.** We could observe cue effects on pain rating comparing ratings classified by social cue mean values for each pain stimulus intensity. Three subjects showed a slight increasing trend in ratings with cues within each intensity.

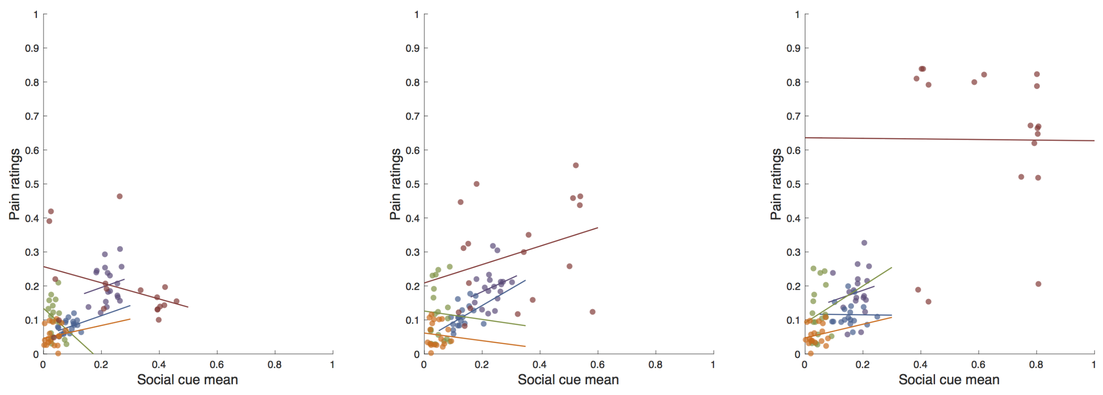

Fig 4. All pain ratings were plotted against social cue mean in three pain intensities in VAS (left – low, middle – medium, right – high).

- **Fig 5. (a)** and **(b)** each show rating trajectories of VAS and SemiC for all subjects (color coded) during rating period in session (c) (**methods**). SemiC trajectories visualize individual trends in rating movement pattern.

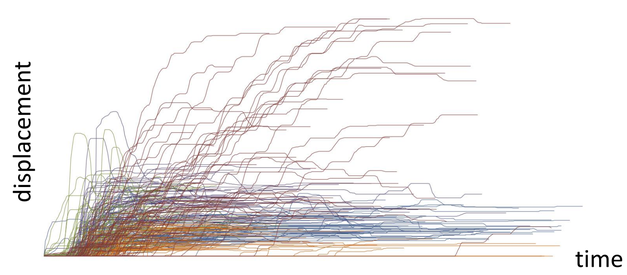

Fig 5 a. Trajectory in VAS: displacement from starting point depending on time.

Fig 5 b. SemiC trajectory: actual path recordings until final rating. Different colors represent each subject.

CONCLUSION

- Observed some proof of construct validity in SemiC
- Analysed cue effects in VAS.
- Compared different trajectory information provided by VAS and SemiC.

FUTURE SUGGESTIONS

- Some problems of the experiment:
  - Calibration was not appropriate to create pain intensity ranges which may have caused inter-subject differences in ratings.
  - Due to error in code, cue selection was not completely randomized to allow equal number of various cues to be used
  - Subjects looking at pressure pain device as pain was given could develop bias.
- Re-evaluate construct validity and cue effects of SemiC.
- With more fMRI data, we could
  - Compare SMA/pre-SMA activation during pain and rating periods
  - Develop a rating movement marker with session (a) data
  - compare the pattern response for VAS and SemiC during pain and rating periods in session (b).
- By applying models of perceptual decision making to SemiC such as predictive coding model [5] and decision diffusion model [4] we could study pain perception.
  - Differences in rating trajectories of SemiC for stimulus intensity with cue levels (mean and SD) may be related to prediction errors of individuals.
  - Drift rate and changes in trajectories may reflect the dynamics of decision making and uncertainty throughout the response [3].

References

[1] neurosynth.org: meta-analysis of fMRI data

[2] Apkarian, A. V., Bushnell, M. C., Treede, R. D., & Zubieta, J. K. (2005). Human brain mechanisms of pain perception and regulation in health and disease. European journal of pain, 9(4), 463-463.

[3] Lepora, N. F., & Pezzulo, G. PLoS computational biology (2015))

[4] Ratcliff, R., Smith, P. L., Brown, S. D., & McKoon, G. (2016). Diffusion decision model: current issues and history. Trends in cognitive sciences, 20(4), 260-281.

[5] Geuter, S., Boll, S., Eippert, F., & Büchel, C. (2017). Functional dissociation of stimulus intensity encoding and predictive coding of pain in the insula. eLife, 6, e24770.