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BOLD Signal Variability Patterns in Neural Correlates of Reflection and Brooding Components of Rumination

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Introduction

RUMINATION

- Rumination is a debilitating symptom, often contributing to depression[1,2].
- Rumination involves self-focused attention (often negative) as a means of coping with a depressed mood[2].
- Two subtypes of rumination:
  - Reflection: thoughts that may help to cope with and overcome problems and difficulties, thought to be adaptive[2].
  - Brooding: passive and judgmental thoughts about one's circumstances, thought to be maladaptive[2].
- Few studies have investigated whether these subtypes are differentially represented in the brain.

NEUROIMAGING

- Neuroimaging research has implicated brain regions within the default mode network (i.e., medial prefrontal cortex (mPFC) and posterior cingulate cortex (PCC)) and dorsolateral prefrontal cortex (dlPFC) in rumination in both healthy and depressed populations[1,3].
- A resting-state fMRI study found evidence for distinct neural correlates of reflection and brooding:
  - Functional connectivity of left amygdala was involved in brooding, while functional connectivity between mPFC, anterior cingulate cortex (ACC), and PCC involved in reflection[4].

BOLD SIGNAL VARIABILITY

- Variability of brain activity, including blood-oxygen level dependent signal variability (BOLD-SV), is often considered beneficial, indicating neural output stability and adaptability[5].
- Optimal levels of BOLD-SV seen in normal functioning systems, whereas aberrant levels of variability can indicate network dysfunction[6], including in depression[7].
- No prior studies have evaluated whether BOLD-SV is differentially related to reflection versus brooding subtypes of rumination in depression.

Predictions

- **Aim 1**: To identify BOLD-SV differences between regions of interest (ROIs) implicated in reflection and brooding rumination.
  - **Hypothesis 1.1**: Reflection and brooding subtypes of rumination will show distinct correlations with BOLD-SV in neural ROIs implicated in rumination.
- **Aim 2**: To determine there are differences in BOLD-SV of the neural regions associated with reflection and brooding based on depression history.
  - **Hypothesis 2.1**: Lower BOLD-SV in ROIs associated with brooding for the currently-depressed group.
  - **Hypothesis 2.2**: Higher BOLD-SV in ROIs associated with reflection for both the past depression and no depression groups.

Methods

- A sample of 79 women were recruited to complete a resting-state fMRI scan, RRS, and BDI-II.
- All resting-state fMRI data were processed using AFNI and FSL according to previous BOLD-SV studies[8].
- For each participant, the standard deviation of the BOLD signal (BOLD-SV) was calculated for the ROIs implicated in rumination: left amygdala, right amygdala, PCC, ACC, dlPFC, and mPFC[4].
- The Ruminative Response Scale (RRS) is a 22-item self-report measure of ruminative thought on a 4-point Likert scale[2].
  - Used two subscales: reflection and brooding.
- BDI-II is a 21-item self-report inventory to measure depression severity[9].

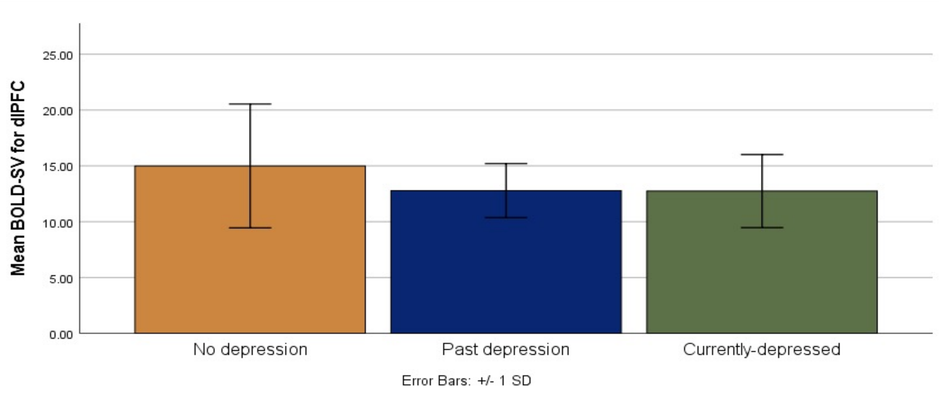
STATISTICAL ANALYSES

- Linear regressions were run to explore the relationship between BOLD-SV and reflection and brooding for each seed ROI.
- The average root mean squared motion was added as a covariate to control for subject movement in these analyses.
- Group differences were assessed using ANCOVA.
- Post Hoc independent samples t-tests were run to further examine differences between groups.

Table 1. Depression Group Characteristics

	NoDep (n=30)		PastDep (n=15)		CurrentDep (n=34)	
	M	SD	M	SD	M	SD
Age	27.13	7.61	28.02	5.85	27.89	7.14
RRS _Brooding	7.97	1.85	10.13	2.59	13.91	3.75
RRS _Reflection	9.67	3.56	11.27	3.35	14.18	3.73
BDI	0.93	1.46	11.33	2.16	20.26	10.76

Figure 1. BOLD-SV Differences in dlPFC Between Depression Groups



Results

- *Aim 1:* There was a significant effect of rumination subtype on BOLD-SV in the dlPFC, *($F_{3,75}$ = 4.86, p=.005).*
- Specifically, greater levels of brooding were associated with lower BOLD-SV in the dlPFC, *(t(78)= -2.612, p=.01).*
- Similar results were found after excluding participants with too much motion *(n=5), (t(73)= -2.383, p=.02).*
- *Aim 2*: There was a significant effect of depression group on BOLD-SV in the dlPFC, *($F_{2,75}$= 3.57, p=.033).*
  - Significantly reduced BOLD-SV in dlPFC in currently-depressed group as compared with no depression group, *(t(63) = -2.436, p=.018).*

Discussion

- Our results yielded significant findings for only one ROI: dlPFC.
- Greater levels of brooding predicted lower BOLD-SV in the dlPFC.
- Within the dlPFC, the no depression group showed significantly higher BOLD-SV than both past depression and currently-depressed groups.
- No significant difference between the past depression and currently-depressed groups is consistent with past research showing changes in BOLD-SV in those with a history of depression[10].
- Our findings suggest reflection and brooding subtypes of rumination may not be uniquely associated with BOLD-SV in DMN or amygdala regions.

LIMITATIONS

- We were limited to a relatively small past-depression group (**Table 1**).
- Research suggests women ruminate more than men[2].
  - Significant results may be due to our sample of only women.

FUTURE DIRECTIONS

- Try to replicate findings in a larger, gender diverse, sample.

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