fMRI data analysis

Part 5: Group Analysis

Group Analysis

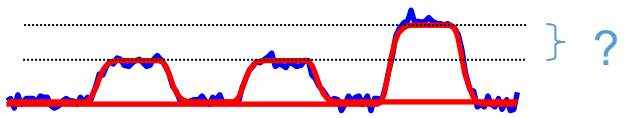
Typical Processing:

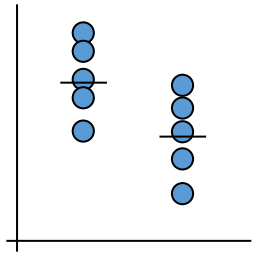
- First level (individual subject)
  - Preprocessing
  - Determine activation amplitude (beta) (& statistics)
- Second Level (Group)
  - Compute statistics from betas across subjects (3dttest++)
  - Compute statistics from betas & stats across subjects (3dMEMA)

Group Analysis

Examples

- What brain areas are active during task A?
  - H_0: avg effect = 0
- What brain areas are more active in task A vs. task B?
  - H_0: β(taskA) = β(task B)
- What brain areas are more active in group 1 vs group 2 for task A?
  - H_0: β(group 1) = β(group 2)

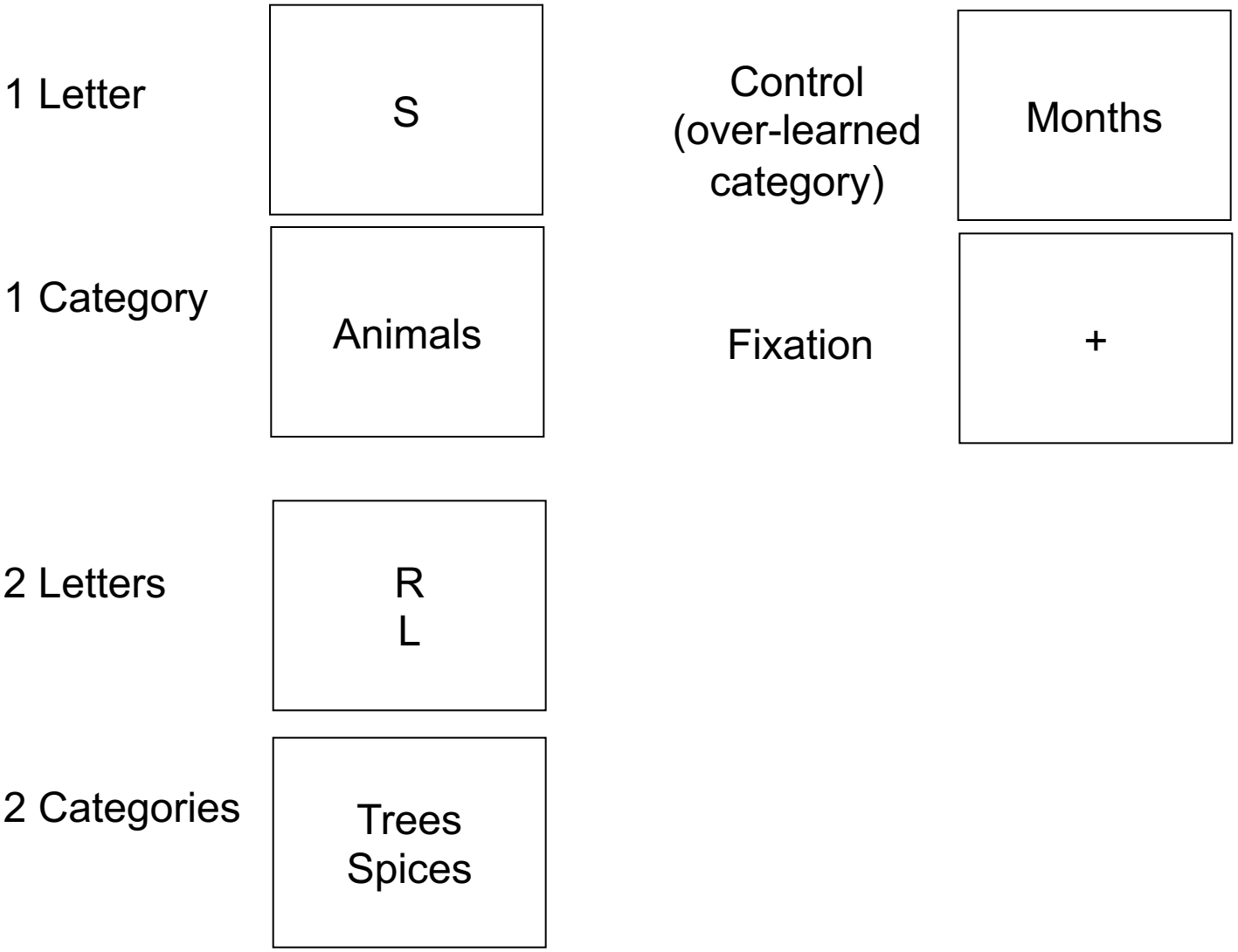




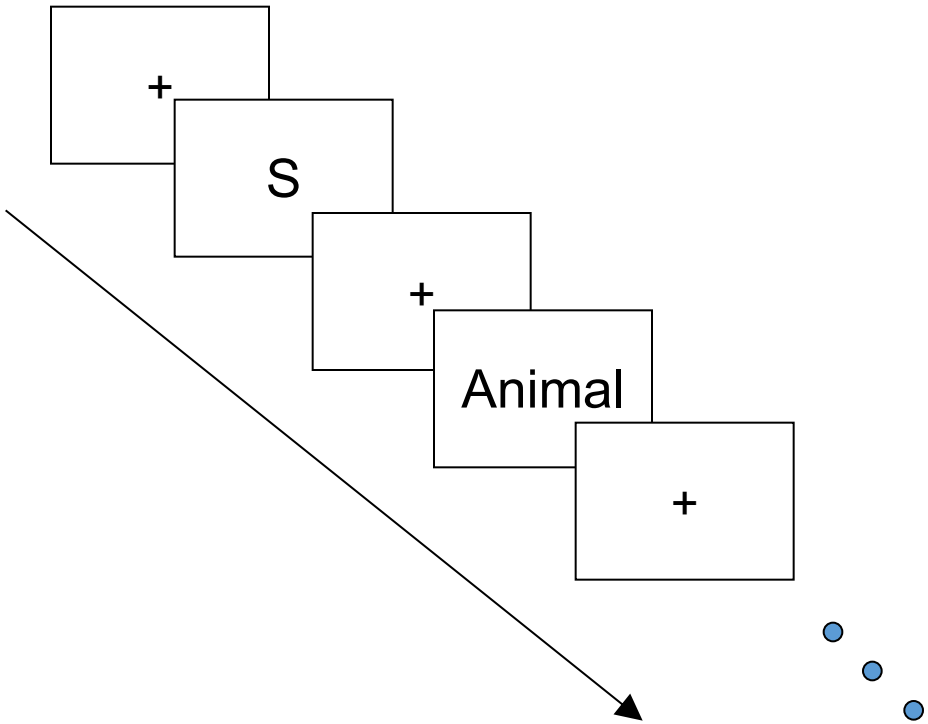
Group Analysis - Definitions

- Factor
  - Can be categorical or quantitative
    - Gender, Group, condition (task), …
    - Age, IQ, stress level, RT, …
  - Can be fixed or random
    - Fixed: Group, condition (task, treatment), …
    - Random: subjects
- Covariate
  - Can be categorical or quantitative
    - Categorical usually converted to number (0,1) or (-1,1)
- Interaction (≥ 2 factors)
  - Is the difference in one factor dependent on another?

Task


1 Letter
S
1 Category
Animals
2 Letters
R
L
2 Categories
Trees
Spices
Control
(over-learned
category)
Months
Fixation
+

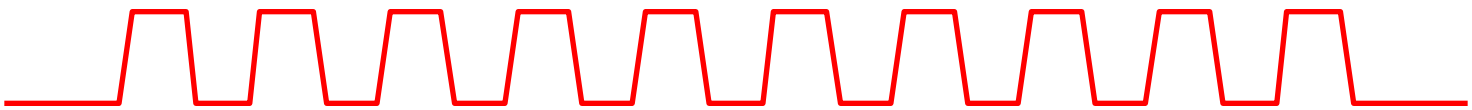
Methods



10 task blocks / run

5 conditions:
- 1 letter
- 2 letters
- 1 category
- 2 categories
- Months

(Each condition twice / run)



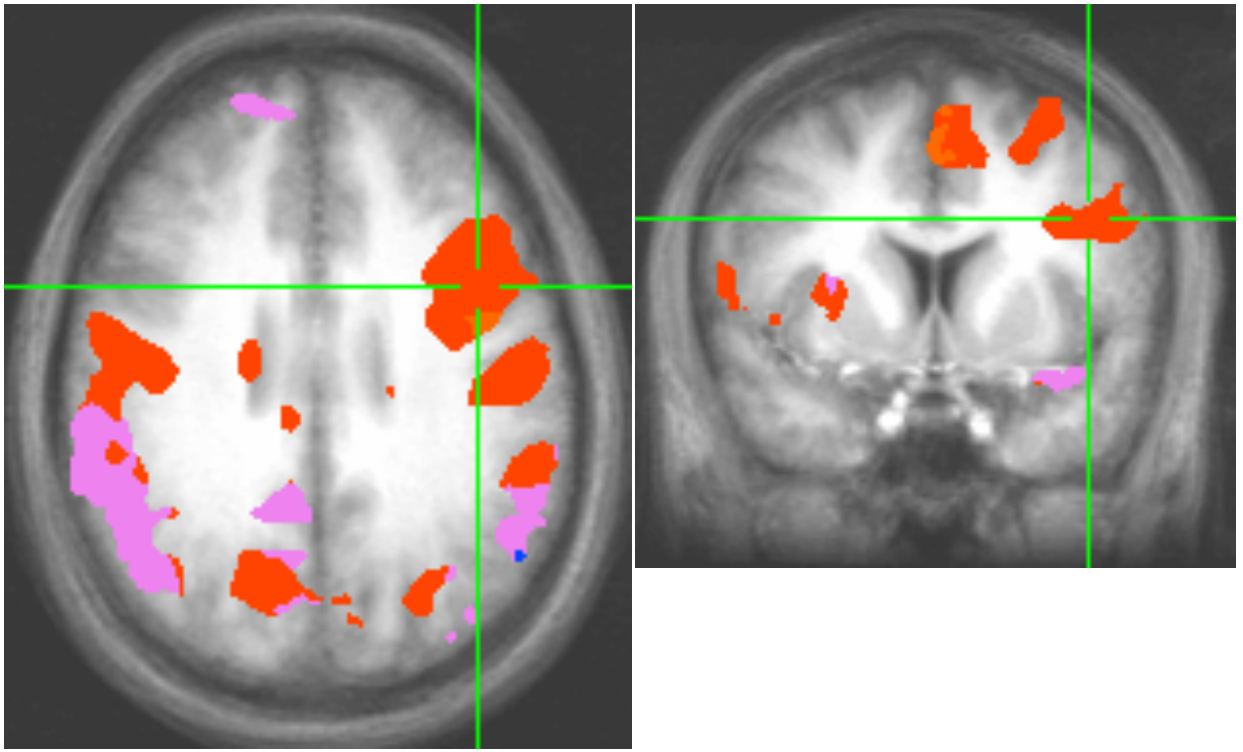
1-sample t-test

What area is active? (all colored areas below)

H_0: $_1L = 0$

(1 group, 1 factor, 1 level)

Letters (1) vs. baseline



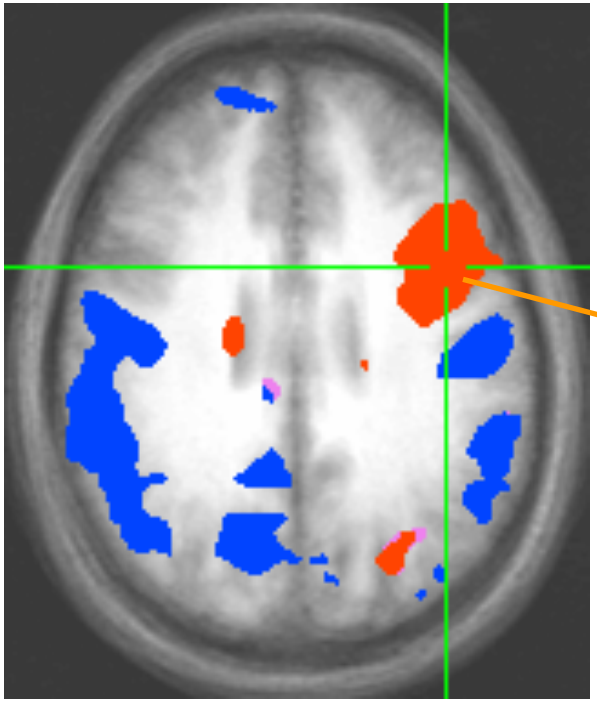
Paired t-test

What area is more active to single letters vs. Months?

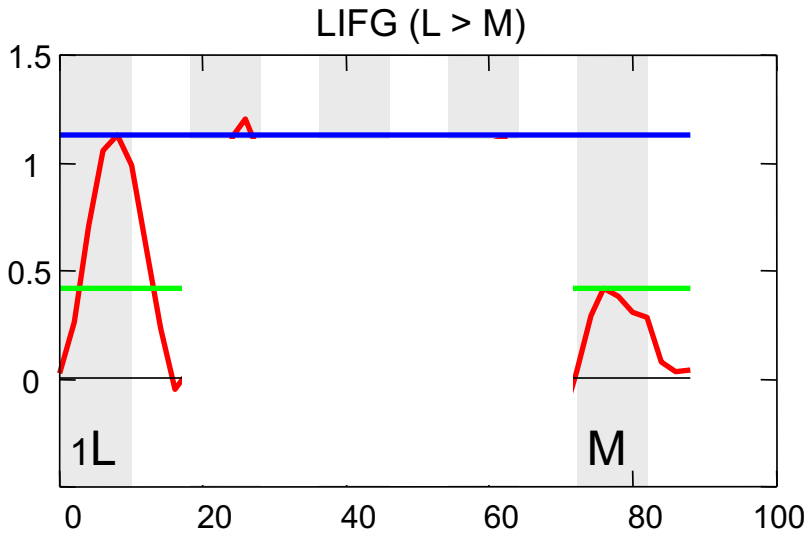
1 group, 1 factor, 2 levels

e.g. 2 task conditions per subject

H_0: $_1$L-M = 0



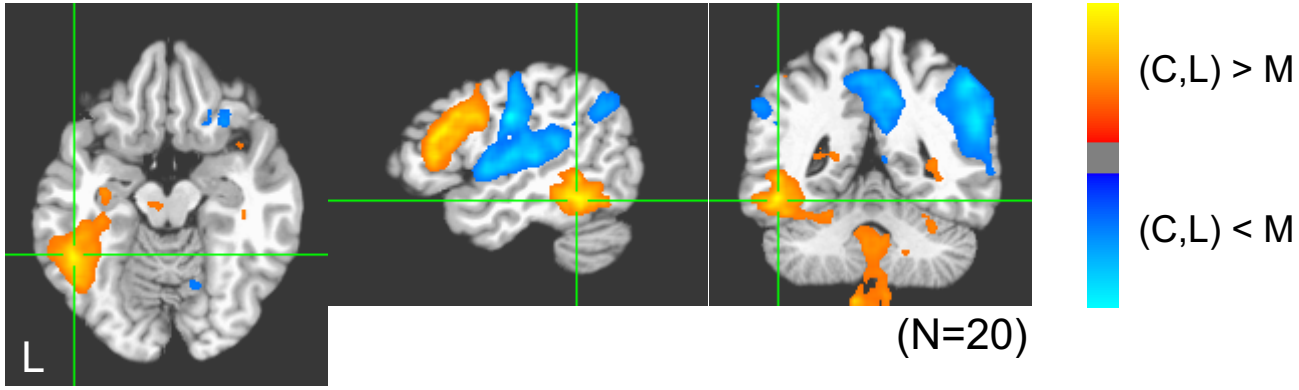
$_1$L-M



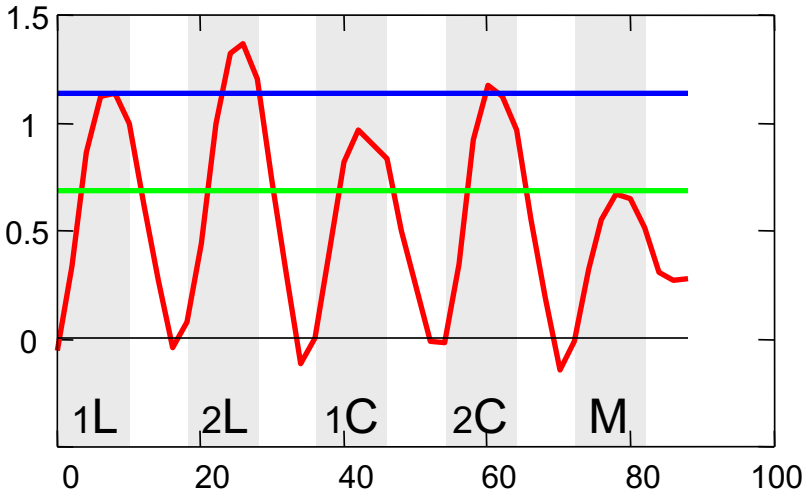
Fluency (Category, Letter) vs. Control (“Months”)

What area is more active to Fluency vs. Control?

TD



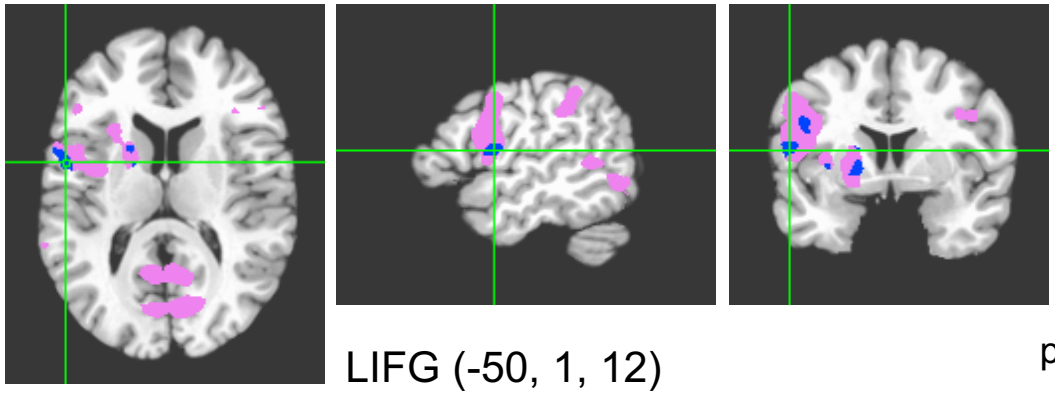
H_0: (C+L)/2 - M = 0



2-sample t-test

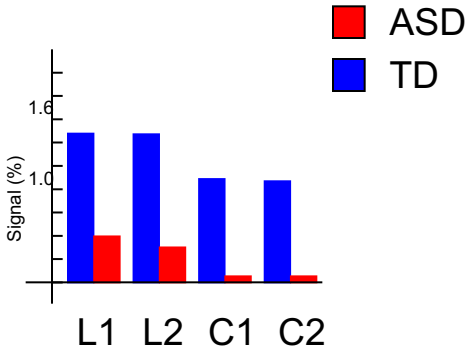
What areas are activated differently in ASD vs. TD?

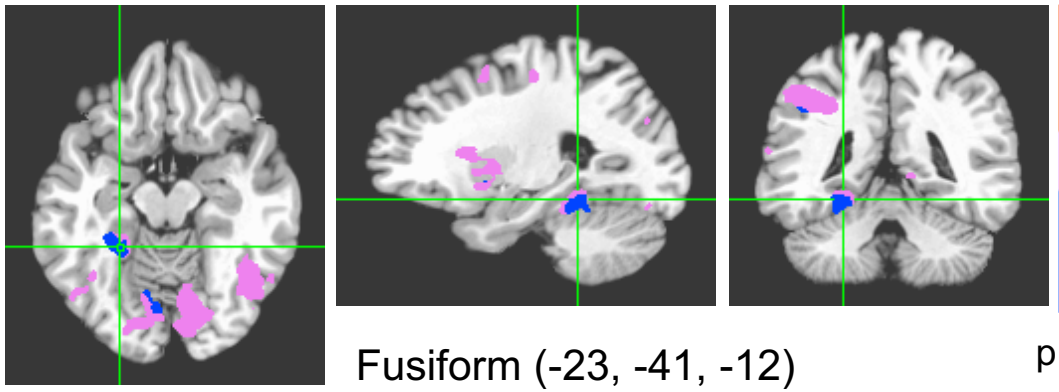
Main effect of Group: ASD vs TD



LIFG (-50, 1, 12)

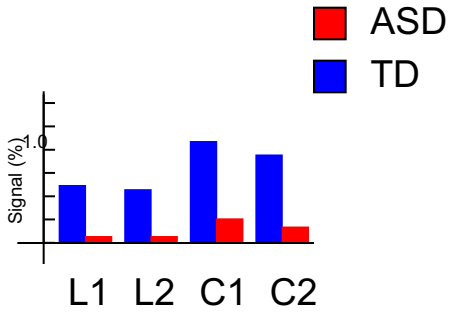
p < 0.001





Fusiform (-23, -41, -12)

p < 0.001



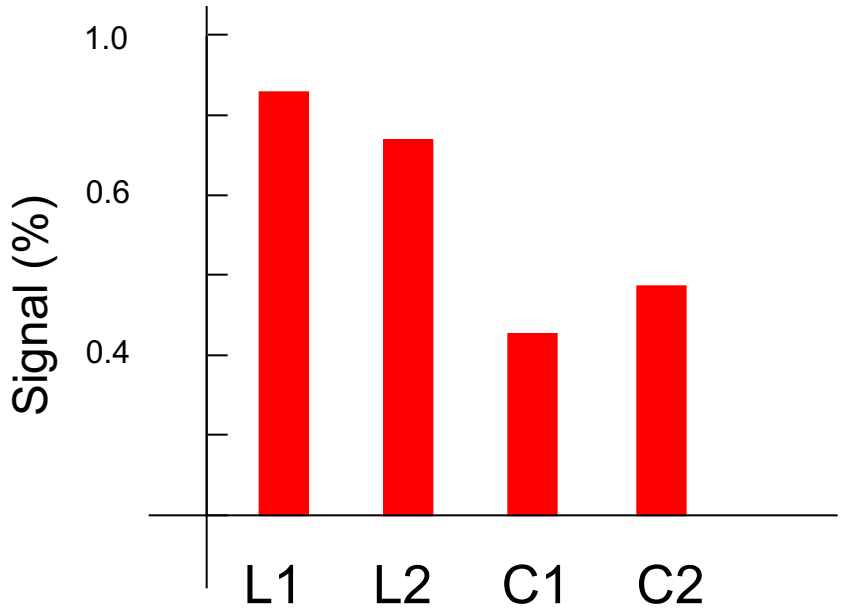
TD = Typically Developing ASD = Autistic Spectrum Disorder

2-way repeated measures ANOVA

Are there brain areas where activity ~ switching (1,2) is different for letters vs. categories (L,C)

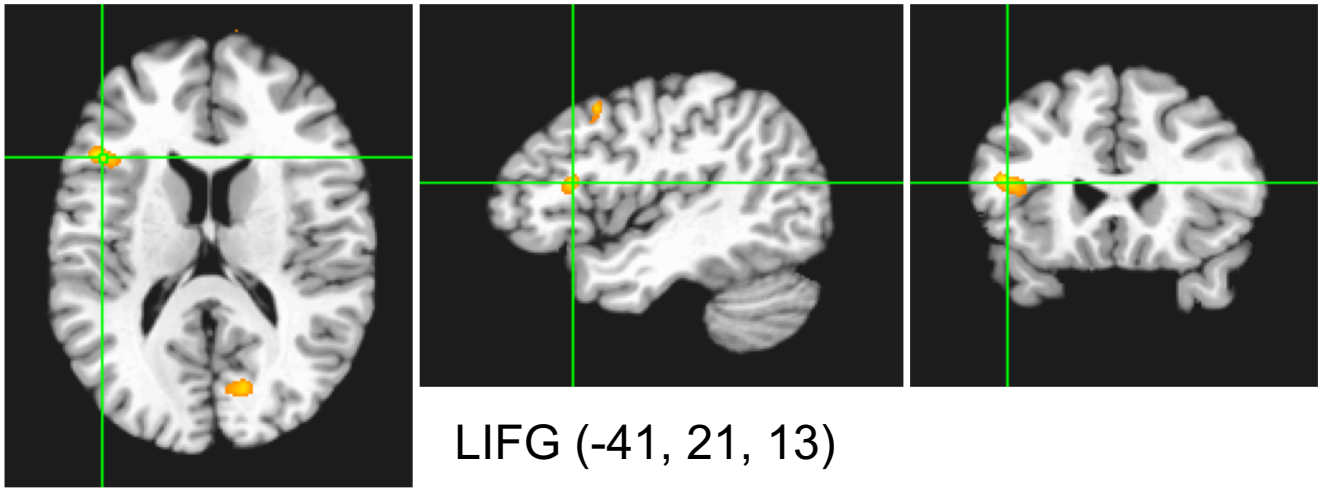
Interaction

e.g. (L,C) x (1,2)

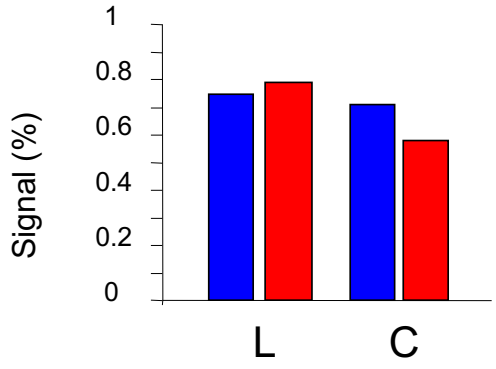


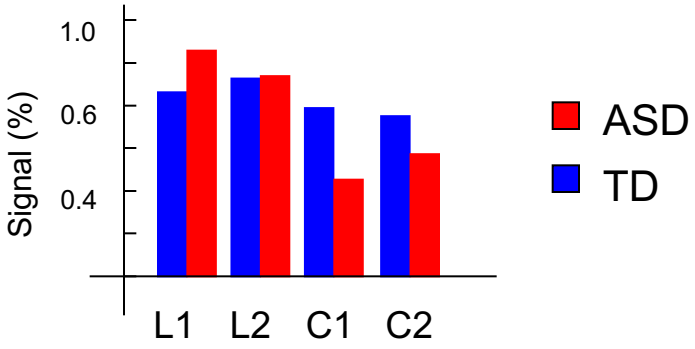
2-way mixed ANOVA

Interaction: Group (ASD,TD) x Task (C,L)



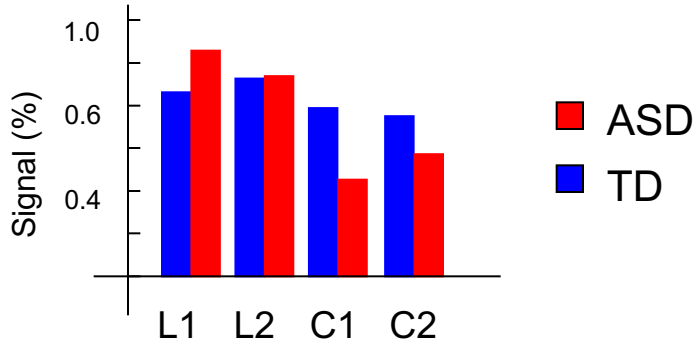
LIFG (-41, 21, 13)



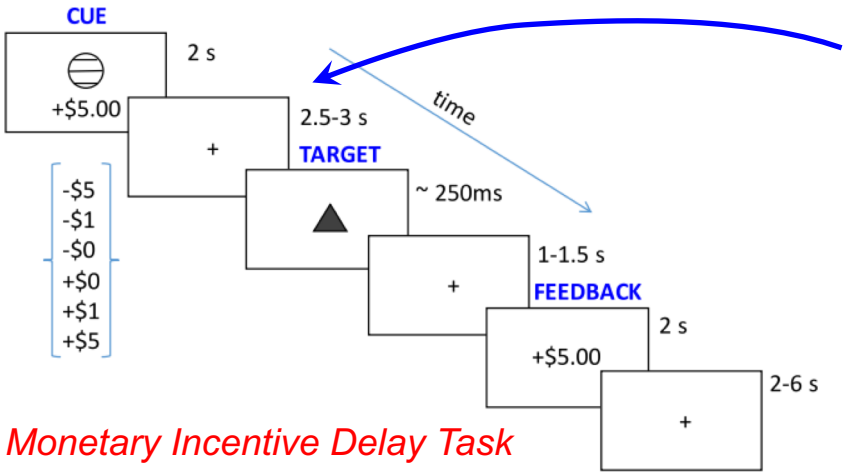


Interactions from > 2 factors

- May be hard to interpret!
  - e.g. (C,L) x (1,2) x (ASD,TD)
- Possible Solutions
  - pair-wise comparisons
  - plot results



Group analysis with Covariates

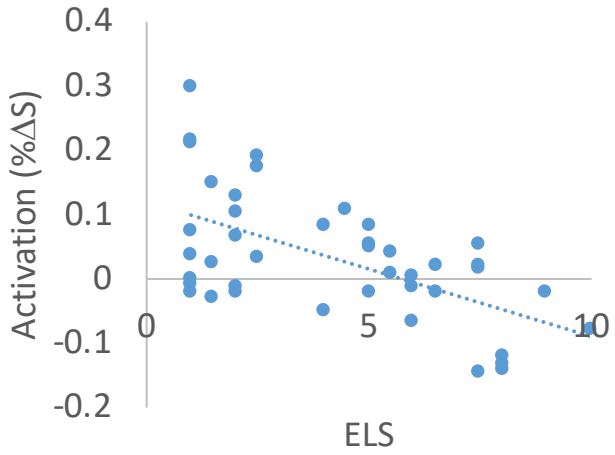


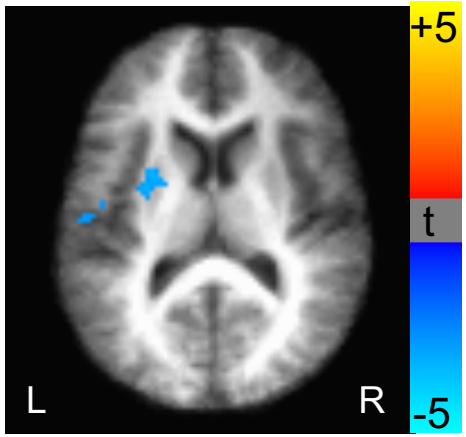
Monetary Incentive Delay Task

Is brain activation during the anticipation of potential loss correlated with early-life stress (ELS)?

- Add ELS as covariate to group analysis

Activation during anticipation of potential loss (-$5) vs. no-loss (-$0)





R.M. Birn et al., PNAS 2017

Summary

- Preprocessing
- Single-subject GLM
  - Choose model (ideal response)
  - Fit the model (get β weight)
  - Determine how good the fit is (t, F, R^2, …)
- Group Analysis
  - Task vs. baseline (1-sample t-test)
  - Task A vs Task B (paired t-test)
  - Group 1 vs Group 2 (2-sample t-test)
  - Interactions (AN(C)OVA)
  - Covariates