midFEMA Manuscript

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Abstract—The midFEMA research project is aimed at identifying and analyzing neurodevelopmental biomarkers for severe behavioral and emotional problems in youth. By leveraging Fast and Efficient Mixed-Effects Analysis (FEMA) in conjunction with voxelwise task-based reward activation measurements, we aim to uncover insights into brain development and functioning across a large, prospectively followed sample of approximately 9,000 youth aged 9–16 years from the Adolescent Brain and Cognitive Development (ABCD) study.

Index terms—Longitudinal, fMRI, DBD, FEMA, MID

```r
library(tidyverse)
```

```
── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──
✔ dplyr     1.1.4     ✔ readr     2.1.5
✔ forcats   1.0.0     ✔ stringr   1.5.1
✔ ggplot2   3.5.0     ✔ tibble    3.2.1
✔ lubridate 1.9.3     ✔ tidyr     1.3.1
✔ purrr     1.0.2
── Conflicts ──────────────────────────────── tidyverse_conflicts() ──
✖ dplyr::filter() masks stats::filter()
✖ dplyr::lag()    masks stats::lag()
ℹ Use the conflicted package (<http://conflicted.
r-lib.org/>) to force all conflicts to become
errors
```

```r
library(ggplot2)

df <- mtcars
str(df)
```

```
'data.frame':  32 obs. of  11 variables:
 $ mpg : num  21 21 22.8 21.4 18.7 18.1 14.3 24.4
22.8 19.2 ...
 $ cyl : num  6 6 4 6 8 6 8 4 4 6 ...
 $ disp: num  160 160 108 258 360 ...
 $ hp  : num  110 110 93 110 175 105 245 62 95
123 ...
 $ drat: num  3.9 3.9 3.85 3.08 3.15 2.76 3.21
3.69 3.92 3.92 ...
 $ wt  : num  2.62 2.88 2.32 3.21 3.44 ...
 $ qsec: num  16.5 17 18.6 19.4 17 ...
 $ vs  : num  0 0 1 1 0 1 0 1 1 1 ...
 $ am  : num  1 1 1 0 0 0 0 0 0 0 ...
 $ gear: num  4 4 4 3 3 3 3 4 4 4 ...
 $ carb: num  4 4 1 1 2 1 4 2 2 4 ...
```

```r
# Set the URL for the CSV file
file_url <- "https://drive.google.com/uc?export=
download&id=1QFdAFz09DQEeFVOj8bRWh4g6hK4b4Qj1"

# Set the destination filename
dest_file <- "df_preclean.csv"

# Download the file
download.file(file_url, destfile = dest_file,
mode = "wb")

# Read the CSV file into R
my_data <- read.csv(dest_file)

# Display the first few rows of the data
head(my_data)
```

```
        subjectid                eventname
site_id_l rel_family_id
1    NDAR_INV003RTV85   1_year_follow_up_y_arm_1
site06          8781
```

```
2  NDAR_INV003RTV85         baseline_year_1_arm_1
site06        8781
3   NDAR_INV003RTV85     18_month_follow_up_arm_1
site06        8781
4   NDAR_INV003RTV85      6_month_follow_up_arm_1
site06        8781
5   NDAR_INV003RTV85     2_year_follow_up_y_arm_1
site06        8781
6   NDAR_INV005V6D2C      6_month_follow_up_arm_1
site10        10210
    sex_at_birth  demo_brthdat_p  race_ethnicity
demo_prnt_income_p demo_prnt_ed_p
1          F             NA           White
NA             NA
2          F             10           White
5             13
3          F             NA           <NA>
NA             NA
4          F             NA           <NA>
NA             NA
5          F             NA           <NA>
NA             NA
6          F             NA           <NA>
NA             NA
                nihtbx_totalcomp_fullycorrected
nihtbx_flanker_fullycorrected
1                    NA                       NA
2                    51                       52
3                    NA                       NA
4                    NA                       NA
5                    NA                       NA
6                    NA                       NA
                 pubertdev_ss_female_category
pubertdev_ss_male_category screentime_ss_weekday
1                    NA                       NA
3.75
2                     3                       NA
2.00
3                    NA                       NA
NA
4                    NA                       NA
NA
5                    NA                       NA
NA
6                    NA                       NA
NA
          screentime_ss_weekend      screentime_13
screentime_wkdy_3 screentime_wknd_9
1               5.0                 0              1
1
2               2.5                 1              1
1
3               NA                 NA             NA
NA
4               NA                 NA             NA
NA
5               NA                  0             NA
NA
```

```
6               NA                 NA             NA
NA
                             cbcl_scr_syn_aggressive_r
cbcl_scr_syn_external_r cbcl_scr_dsm5_opposit_r
1                      0                             1
0
2                      0                             1
0
3                     NA                            NA
NA
4                     NA                            NA
NA
5                     NA                            NA
NA
6                     NA                            NA
NA
  cbcl_scr_dsm5_conduct_r cbcl_scr_dsm5_opposit_t
cbcl_scr_dsm5_conduct_t
1                      0                            50
50
2                      0                            50
50
3                     NA                            NA
NA
4                     NA                            NA
NA
5                     NA                            NA
NA
6                     NA                            NA
NA
  cbcl_scr_syn_internal_r cbcl_scr_dsm5_depress_r
ksads_15_902_p ksads_15_901_p
1                      1                             1
0              0
2                      1                             0
0              0
3                     NA                            NA
NA             NA
4                     NA                            NA
NA             NA
5                     NA                            NA
0              0
6                     NA                            NA
NA             NA
           ksads_16_897_p        ksads_16_899_p
cbcl_q26_p
1              0                 0 Not True /No es
cierto (que sepa usted)
2              0                 0 Not True /No es
cierto (que sepa usted)
3             NA                NA
<NA>
4             NA                NA
<NA>
5              0                 0 Not True /No es
cierto (que sepa usted)
6             NA                NA
<NA>
```

```
                                    prosocial_q1_p
prosocial_q2_p
1 Certainly True /Totalmente cierto    Certainly
True /Totalmente cierto
2 Certainly True /Totalmente cierto    Somewhat
True /Algo cierto
3                                      <NA>
<NA>
4                                      <NA>
<NA>
5 Certainly True /Totalmente cierto    Certainly
True /Totalmente cierto
6                                      <NA>
<NA>
                  prosocial_q3_p
1      Somewhat True /Algo cierto
2 Certainly True /Totalmente cierto
3                           <NA>
4                           <NA>
5      Somewhat True /Algo cierto
6                           <NA>
```

A. Introduction

Introduce the research topic, state the research problem, and outline the study's objectives. Provide background information to set the context. This is an exmaple in-text citation [1]. Dolor velit velit erat egestas egestas, purus purus urna, eros sociosqu! Orci per vivamus phasellus, diam hac mauris tempus aenean mus integer aenean cras. Parturient suspendisse viverra blandit rutrum fringilla erat penatibus vehicula. Na vehicula!

Consectetur nibh eleifend hac, parturient, phasellus, pellentesque tempor et feugiat. Nec mus lobortis egestas sollicitudin hendrerit vehicula faucibus condimentum dignissim nec. Aliquet sagittis imperdiet; faucibus, lectus egestas inceptos.

Amet fermentum fames ut auctor turpis: curae morbi, viverra primis nostra ullamcorper. Dui est sollicitudin neque rhoncus molestie curabitur sociosqu. Cum mollis et fringilla donec nam; laoreet; suspendisse montes aptent viverra etiam. Cubilia fames quis hendrerit metus nam suspendisse vulputate vivamus? Vulputate ultricies donec rutrum massa, consequat sem dapibus lectus facilisi ullamcorper magnis nam. Diam rhoncus non lacinia curabitur lacinia: natoque sapien posuere malesuada quisque eros nascetur odio turpis taciti orci.

1) Background: Provide a brief review of the pertinent literature, highlighting the gaps your study aims to fill. Consectetur hac porttitor himenaeos egestas, gravida magnis, purus ultricies inceptos pharetra vitae pellentesque. Parturient integer porttitor tellus commodo porta posuere, risus hendrerit habitasse accumsan auctor rutrum. Consequat volutpat mattis id tristique habitant lacinia non etiam lacinia, lobortis interdum netus pharetra? Semper pellentesque curae natoque congue consequat. Fusce viverra enim semper, nam imperdiet laoreet imperdiet blandit.

Adipiscing bibendum posuere vulputate cras elementum magna; nec pellentesque congue – sem velit imperdiet. Nec praesent aliquam massa ridiculus, porttitor vitae in arcu cubilia facilisi facilisi nec. Quis hendrerit integer diam; et, netus ultrices tempus!

2) Objectives: State the specific research questions or hypotheses your study addresses. Adipiscing morbi curabitur, fames facilisi arcu aptent nibh non enim augue? Nibh augue dictum vivamus nisl; vestibulum leo blandit odio magnis risus.

Dolor nostra sociis tristique convallis fames mi velit ante dignissim senectus.

B. Methods

Describe the methodological approach, detailing how the study was conducted, how data was collected, and how analyses were performed. Adipiscing mi habitasse – aliquam donec: vitae proin viverra purus. Pretium pulvinar suspendisse curae volutpat suscipit venenatis ornare phasellus dictum. Mollis venenatis lobortis consequat, leo: penatibus vel posuere, eu ligula risus. Cras rutrum auctor suspendisse platea – nibh potenti sagittis vehicula, porttitor odio ornare dignissim?

1) Participants: Describe the demographic characteristics of the study participants, including how they were selected, recruited, and any inclusion or exclusion criteria. Adipiscing suscipit faucibus morbi, augue nostra pretium cras. Mattis ac mollis nullam nec et malesuada egestas lacinia, libero mauris curabitur! Nulla lectus ad egestas iaculis eros, condimentum bibendum curae sodales! Nisi vivamus eleifend risus bibendum, orci litora fermentum id cum nostra odio ullamcorper rutrum molestie auctor natoque phasellus eget.

2) Measures: List the instruments or tools used to collect data, describing each measure's purpose and any relevant psychometric properties. Elit sodales, eros viverra, quisque, augue curabitur ornare et ligula lobortis! Nulla cras risus turpis; suscipit congue ultricies ut dictum sodales himenaeos! At quisque tellus facilisi molestie ad augue id montes, dignissim, quis mi! Tempor tempor.

Sit cubilia magnis, taciti neque netus, vivamus, netus pharetra luctus proin. Tincidunt vitae mollis: ornare tempus lectus ante cursus maecenas! Sapien nascetur sollicitudin sociosqu ut facilisis; nullam; malesuada tristique a, purus per sodales risus neque!

3) Analytic Plan: Detail the statistical tests or models employed to analyze the data, including any software used. Sit non risus ullamcorper faucibus potenti consequat fermentum vel nostra quis imperdiet tempor morbi.

C. Results

Present the findings of the study, supported by statistical analysis, tables, and figures as necessary. Amet cum pellen-

tesque dis duis sed tellus penatibus torquent, aliquam cum sodales. Fames rutrum himenaeos natoque netus viverra egestas arcu nisl.

Consectetur laoreet rhoncus lobortis, semper, vulputate cubilia, aliquam vivamus hac massa. Taciti senectus sollicitudin ullamcorper pellentesque non bibendum. Mauris sodales neque: sapien, parturient facilisi proin natoque malesuada. Fermentum erat mus purus posuere ridiculus interdum! Sociis eu at a congue est volutpat. Habitasse vestibulum enim taciti suscipit elementum tellus platea potenti. Tortor tempor dictumst aenean suscipit orci, turpis morbi, lacus ante vestibulum mus molestie tristique.

Dolor lectus auctor, tempus fames faucibus aliquet donec, habitant non penatibus? Erat sollicitudin ac netus conubia malesuada; eu quis magnis? Urna risus urna commodo etiam, curae ornare hac praesent. Inceptos nunc phasellus penatibus cum et ante cum congue; enim metus. Vulputate sapien odio cursus praesent.

1) *[Subsection Title]: Present specific findings related to a particular aspect of the study, supported by data.* Sit pretium nascetur elementum, curabitur, lacus pellentesque massa himenaeos iaculis etiam? Conubia duis vitae elementum varius. Sem hendrerit lacinia cursus nullam potenti turpis nam urna. Dis iaculis urna interdum erat pharetra pellentesque dui cubilia magnis habitant purus purus class nunc. Urna facilisis nunc proin nisi mus convallis turpis mollis.

2) *[Subsection Title]: Discuss another set of findings, providing details on the analysis and interpretation.* Amet tellus justo, eu rutrum mauris! Fermentum risus porttitor nec vel inceptos rutrum fermentum massa scelerisque feugiat litora, lacinia porta netus. Condimentum fringilla eleifend luctus nec nibh facilisis primis penatibus mi nostra.

D. Discussion

Interpret the results, discussing their implications in the context of existing literature. Address the study's limitations and suggest directions for future research. Sit etiam mauris per; id, in egestas mollis urna orci platea. Faucibus potenti, proin nisl ultricies facilisis per. Euismod lacinia sagittis cum tempor. Dapibus porttitor nam blandit platea nisi – torquent nulla. Vitae dignissim dapibus luctus porttitor nullam lobortis scelerisque nec curabitur dignissim nisi enim vivamus viverra per penatibus?

Adipiscing pretium, aenean, suspendisse mauris ut blandit cras arcu fringilla. Aenean facilisi tellus sociosqu primis nunc orci nisl, dis aenean neque. Urna aptent ultrices sed, tortor varius sem diam, laoreet dignissim non? Taciti risus cum interdum sollicitudin nascetur nostra nullam habitant blandit tellus tellus? Nostra dignissim vitae dictumst orci enim pulvinar auctor sociis accumsan turpis. Convallis nec rutrum natoque.

Dolor dui dis facilisi lectus, mus tristique tincidunt hendrerit imperdiet! Sociis tristique luctus lacus purus etiam ut

taciti, platea vitae. Sodales dis diam fusce tellus ultricies mauris facilisi montes id? Mollis consequat eros pellentesque viverra rutrum conubia – et quam urna! Nullam sociosqu mattis etiam neque dis convallis – cras fames et urna. Na urna.

1) *Limitations: Acknowledge any limitations of your study and their potential impact on the findings.* Adipiscing aliquam praesent faucibus. Et lobortis neque tristique cum semper dis commodo blandit nostra? Platea ligula netus, montes molestie accumsan! Aliquam litora velit quis dapibus – tellus urna nunc: iaculis accumsan blandit, ac velit aenean porta dapibus sagittis eu cubilia.

2) *Future Directions: Suggest areas for future research that could build on your findings or address limitations.* Sit hac, inceptos porttitor nisl metus magnis primis ante a magnis mauris aptent. Turpis interdum habitant cras lobortis cubilia, vehicula vehicula habitant, ut mi. Dignissim lobortis nunc morbi odio?

E. Conclusion

Summarize the main findings and their implications. Conclude with a statement that reflects the significance of the study and its contributions to the field. Ipsum dui, gravida facilisi at luctus felis enim. Suscipit morbi hac: maecenas ligula mus at fermentum.

F. Acknowledgments

Acknowledge anyone who contributed to the research but does not meet authorship criteria, along with any funding sources. Sit molestie sapien litora dignissim diam curabitur: tortor torquent ultricies. Fermentum viverra eget placerat diam vitae suscipit, tempus integer iaculis diam pellentesque enim! Eros class imperdiet ornare, quam sapien viverra.

G. Appendices

Include any additional material that is pertinent to the study but would be too distracting or bulky to include in the main body of the manuscript. Lorem augue natoque cubilia consequat mattis, nostra proin nostra: urna mattis est! Ornare quisque hac at integer ante class nostra hac, nisi per ut conubia. Vivamus praesent eleifend facilisis est porta tellus gravida nullam eros libero. Inceptos aliquam montes ad interdum nulla iaculis vivamus? Ligula nam tristique maecenas aliquet pellentesque, auctor vel diam. Inceptos eu, leo tincidunt eu feugiat vulputate enim hendrerit lobortis aenean at. Na at!

Bibliography

[1] R. Astley and L. Morris, "At-scale impact of the Net Wok: A culinarically holistic investigation of distributed dumplings", *Armenian Journal of Proceedings*, vol. 61, pp. 192–219, 2020.