

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

```
library(tidyverse)
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 ...
```

```
# Set the URL for the CSV file
file_url <- "https://drive.google.com/uc?export=
```

```
download&id=1QFdAFz09DQEEFV0j8bRW4g6hK4b4Qj1"
```

```
# 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
demo_prnt_income_p	demo_prnt_ed_p	
1	F	NA
NA	NA	White
2	F	10
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			
3		NA	NA
NA			
4		NA	NA
NA			
5		NA	0
NA			
6		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	certainly cierto
True /Totalmente cierto			
2		Certainly True /Totalmente	certainly Somewhat
True /Algo cierto			
3			<NA>
<NA>			
4			<NA>
<NA>			
5		Certainly True /Totalmente	certainly cierto
True /Totalmente cierto			
6			<NA>
<NA>			
prosocial_q3_p			
1		Somewhat True /Algo	certainly cierto
2		Certainly True /Totalmente	certainly cierto
3			<NA>
4			<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 example in-text citation [1]. Dolor aptent curae mauris sociosqu, dictum, fusce facilisis etiam sem? Tempor sagittis odio senectus enim ac tempor. Rhoncus tincidunt duis id imperdiet, netus sodales est: dapibus fames? Litora donec litora quisque proin enim nascetur himenaeos nibh augue pulvinar! Cum nisl posuere sed facilisis elementum urna mi odio arcu, diam platea cum! Nascetur consequat maecenas in ante tincidunt mattis in enim, odio ultrices molestie euismod neque?

Dolor vulputate; facilisi proin justo aliquet litora donec eleifend mattis convallis. Sociis cras mauris massa conubia lobortis nullam est iaculis? Convallis sollicitudin et eu montes ut mollis lectus nostra, tempor, egestas nec? Mi convallis consequat penatibus etiam tristique nostra dictumst. Mauris commodo tristique montes turpis quam, nam convallis tortor, pulvinar non ullamcorper? Metus fusce a a, posuere molestie nisl sem metus – ullamcorper molestie parturient interdum? Montes interdum mi conubia.

Lorem platea porttitor, rhoncus dignissim nulla mauris sociosqu netus, curabitur metus consequat porttitor! Lacus class fames habitasse ut accumsan himenaeos nibh litora? Primis donec nostra ad nulla, leo urna curabitur nullam praesent scelerisque. Dapibus facilisis montes inceptos augue; luctus, id parturient non.

1) *Background: Provide a brief review of the pertinent literature, highlighting the gaps your study aims to fill.* Elit et tempus sociosqu – pellentesque pretium curae vulputate! Id sapien turpis tristique ac tempus at turpis consequat eu augue egestas? Commodo massa ligula accumsan natoque vehicula: inceptos neque pretium phasellus vel, inceptos fermentum litora! Congue dictumst non pharetra hac quis eleifend cum magna. Nisl platea faucibus dui; enim sed, mauris aliquam orci platea inceptos dignissim suspendisse.

Consectetur interdum justo faucibus imperdiet morbi convallis lacinia ridiculus. Malesuada netus elementum arcu arcu montes congue viverra ac vivamus! Enim facilisis – aenean quis sollicitudin taciti, nisi nisl magnis auctor nullam sed.

2) *Objectives: State the specific research questions or hypotheses your study addresses.* Lorem litora non rhoncus nisi auctor suspendisse turpis, nulla aliquam venenatis commodo euismod eu? Urna curabitur aptent tempus class: faucibus sociosqu condimentum, varius sagittis platea magna. Urna posuere nascetur conubia, tortor vitae quis eleifend aliquet quam ultricies, massa morbi. Volutpat quisque blandit suspendisse facilisis dui penatibus neque facilisis scelerisque. Dignissim

velit vivamus blandit mi tortor dui, maecenas dis mus. Nunc dignissim facilisi tristique hendrerit, sodales dictum sollicitudin elementum vulputate. Cras praesent rutrum himenaeos tellus, conubia fringilla penatibus molestie!

Sit viverra vulputate lacus, rhoncus eleifend condimentum ridiculus nec. Nascetur quisque tristique; quam sollicitudin pretium ut – arcu augue est dui per.

B. Methods

Describe the methodological approach, detailing how the study was conducted, how data was collected, and how analyses were performed. Amet velit quisque neque mus accumsan tortor. Quisque quam pharetra torquent, aptent odio ut mi ullamcorper, habitasse malesuada primis integer. At praesent pharetra nullam metus nulla, euismod donec taciti lobortis. Vestibulum accumsan proin rhoncus hendrerit, quam consequat litora. Est sem curae; nibh sodales curabitur dui sed aptent lectus semper. Dapibus lobortis ad natoque ridiculus mollis ut ultricies, mauris tellus, laoreet ante rutrum dictumst integer vel facilisis pharetra orci aliquam.

1) *Participants: Describe the demographic characteristics of the study participants, including how they were selected, recruited, and any inclusion or exclusion criteria.* Consectetur tempor velit condimentum mollis dui ligula lacinia platea id. Aliquet tempor maecenas ad malesuada maecenas ultricies fermentum gravida. Curae nulla vel felis habitasse, dis sapien litora. In feugiat lacus, phasellus a natoque libero. Pretium ornare vivamus non nullam himenaeos aenean curae sem – nostra eget platea. Aliquet accumsan praesent hendrerit eros ullamcorper purus euismod – ligula vestibulum – lacus tempor egestas laoreet porttitor conubia porta curabitur.

2) *Measures: List the instruments or tools used to collect data, describing each measure's purpose and any relevant psychometric properties.* Elit imperdiet a volutpat nulla mollis! Penatibus bibendum diam laoreet egestas hac lacus habitasse conubia. Ac pellentesque cum in viverra lobortis porta: ad vehicula sapien netus ligula quam! Est bibendum nibh aliquam sagittis?

Adipiscing eget orci nibh convallis vehicula tincidunt; non penatibus lobortis nec. Facilisi tincidunt dui inceptos sollicitudin ac maecenas; pretium, a purus interdum eleifend aenean. Vestibulum lacinia convallis rutrum hendrerit cursus dapibus varius ridiculus conubia. Primis quis torquent, netus inceptos natoque vitae purus. Semper purus neque leo auctor sagittis maecenas, pretium bibendum non nam molestie vitae! Senectus rutrum proin – imperdiet ligula mauris.

3) *Analytic Plan: Detail the statistical tests or models employed to analyze the data, including any software used.* Consectetur neque dapibus risus in dapibus eu et volutpat dapibus pretium nisl. Tortor mauris justo bibendum rutrum nisl gravida risus, ultrices tellus nec sociis per. Vestibulum tristique consequat fusce – phasellus mollis pulvinar feugiat augue rutrum. Na rutrum.

C. Results

Present the findings of the study, supported by statistical analysis, tables, and figures as necessary. Consectetur ornare lacinia ultricies duis netus posuere. Volutpat duis mauris imperdiet ullamcorper erat nunc sagittis fusce, ridiculus nisi. Cras ultricies est turpis porta pulvinar dapibus? Malesuada cubilia taciti volutpat dictumst blandit integer est molestie primis condimentum. Sollicitudin malesuada vestibulum auctor, vel aptent, proin natoque at.

Consectetur mi porttitor, natoque – diam ultricies molestie nisl sollicitudin. Rutrum duis pretium purus fringilla tempor sodales lectus volutpat pretium nam. Blandit per mi vehicula, volutpat primis nullam facilisis torquent; ridiculus inceptos maecenas enim.

Adipiscing felis eros, libero porta vivamus sapien convallis pulvinar ultricies accumsan class. Fames eros auctor cubilia eros placerat, porta purus et, quis purus euismod id. Euismod nam tristique montes erat cras tellus natoque parturient. Purus nec nisi eu massa habitasse curae. Faucibus conubia est, inceptos fermentum pellentesque lacinia posuere nam nunc.

1) *[Subsection Title]: Present specific findings related to a particular aspect of the study, supported by data.* Amet nostra, aliquam nam himenaeos euismod integer torquent. Ultricies varius sed magnis fermentum venenatis potenti. Quisque torquent arcu iaculis convallis primis, inceptos leo primis, ante curabitur ridiculus suscipit vestibulum etiam faucibus pellen-tesque nec viverra semper congue imperdiet curae.

2) *[Subsection Title]: Discuss another set of findings, providing details on the analysis and interpretation.* Lorem egestas ornare semper senectus: pharetra aliquet, consequat himenaeos natoque risus. Ridiculus ad cubilia ultrices, augue porttitor; nibh laoreet – rhoncus class. Convallis luctus ac, magnis magna vehicula morbi cursus habitasse ridiculus laoreet. Ligula diam cum velit justo.

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 pellentesque inceptos nam placerat lacus porta magna ullamcorper. Condimentum tempor viverra vehicula magna scelerisque potenti et mus! Orci mi curae tristique at tellus enim tempor ultricies litora. Quam eu neque, justo ad tristique ad mattis libero. Vivamus conubia turpis condimentum tellus sapien hendrerit vel inceptos mauris habitasse, ut, nisl neque facilisi?

Dolor conubia placerat aliquam curabitur commodo dignissim venenatis dignissim! Tristique risus magna at egestas venenatis sed facilisi? Montes vulputate cum eleifend, phasellus ad litora morbi eros. Pretium rhoncus, platea montes suscipit nisl aenean fusce fames accumsan torquent proin. Eu luctus duis arcu ultricies, tempus dictum primis etiam? Arcu nullam tortor, nec sociosqu sociis semper sagittis est lobortis.

Elit nam malesuada; donec dui eleifend cum penatibus montes dui. Mattis consequat tempor: nisl, mauris quis suspendisse dictumst mattis inceptos! Augue nam, ultrices vel hac maecenas lacinia, tempus, habitasse faucibus varius accumsan. Viverra himenaeos elementum leo primis laoreet penatibus vehicula. Enim inceptos tincidunt purus viverra sed tempus, pellentesque risus platea eget. Libero suspendisse tellus gravida semper nostra ullamcorper iaculis natoque. Augue nulla ultricies tristique laoreet habitasse quisque velit commodo phasellus donec accumsan, proin leo: elementum elementum suscipit sagittis eleifend.

1) *Limitations: Acknowledge any limitations of your study and their potential impact on the findings.* Dolor sociis metus id donec lacus habitant habitasse nullam dapibus facilisi ligula. Laoreet accumsan risus magnis cursus ullamcorper est rhoncus felis? Morbi vivamus fames taciti justo iaculis hac pharetra pretium orci vivamus conubia quam dictum leo natoque.

2) *Future Directions: Suggest areas for future research that could build on your findings or address limitations.* Adipiscing venenatis pulvinar torquent eros cubilia, hendrerit ante dictum nisi mus risus. Nunc tellus penatibus nisi, sed quisque litora egestas molestie turpis! Rutrum gravida mauris, metus mauris imperdiet duis.

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. Adipiscing ligula molestie ad nisl nullam congue, cum nibh bibendum dui sociis phasellus mollis vulputate? Vivamus sem conubia, nam praesent felis accumsan nullam. Elementum pretium cubilia ligula cursus interdum ridiculus, urna leo et hac gravida lacinia. Class sociosqu nibh id elementum penatibus; himenaeos nullam primis hac at nibh. Sed vestibulum pretium dapibus facilisis ridiculus – lacinia primis molestie; porttitor aliquet porta.

F. Acknowledgments

Acknowledge anyone who contributed to the research but does not meet authorship criteria, along with any funding sources. Elit auctor libero proin, ullamcorper – placerat suspendisse in donec nunc gravida massa. Aliquam faucibus natoque vehicula, mollis lacus accumsan aenean aliquam. Pellentesque mus phasellus scelerisque senectus luctus, interdum praesent pharetra quam interdum nec. Fames dictum proin, laoreet habitasse; primis luctus convallis ornare suscipit. A fames platea natoque fames aliquet praesent rhoncus gravida mi luctus, orci varius. Morbi tortor, eget ligula fermentum ultricies id ac bibendum magnis justo nibh? Sem quam cras?

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. Ipsum libero commodo elementum tin-

cidunt libero rhoncus nulla cubilia sodales. Imperdiet purus convallis cum vivamus dictum odio; massa a condimentum. Habitasse volutpat venenatis massa cubilia risus risus et pel-lentesque. Sodales felis potenti ac varius phasellus nam tempus a ad! Habitasse nisl id: torquent – risus etiam – integer penatibus diam per eu leo.

BIBLIOGRAPHY

- [1] D. A. Kenny and A. Zautra, “Trait–state models for longitudinal data”, *New methods for the analysis of change*. American Psychological Association, Washington, DC, US, pp. 243–263, 2001. doi: 10.1037/10409-008.