



# Youth Screen Media Activity Patterns and Associations with Behavioral Developmental Measures and Resting-state Brain Functional Connectivity

Kunru Song

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State Key Laboratory of Cognitive Neuroscience  
and Learning, Beijing Normal University



# Details could be found here!

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NEW RESEARCH

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Introduction

Methods

Results

Discussion

Summary

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## Youth Screen Media Activity Patterns and Associations With Behavioral Developmental Measures and Resting-state Brain Functional Connectivity

Kunru Song, BSc , Jia-Lin Zhang, MSc , Nan Zhou, PhD , Yu Fu, BSc , Bowen Zou, BSc , Lin-Xuan Xu, BSc , Ziliang Wang, MSc, Xin Li, BSc , Yihong Zhao, PhD , Marc Potenza, PhD , Xiaoyi Fang, PhD , Jin-Tao Zhang, PhD

Editorial Review for Our Article

EDITORIAL

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## Editorial: Benign Versus Problematic Media Use Profiles in Youth: Correlates, Concerns, and Future Directions

Lauren Eales, MA, Andrea Wiglesworth, MA, Bonnie Klimes-Dougan, PhD,  
Kathryn R. Cullen, MD





# Youth Developing in Digital World

Introduction

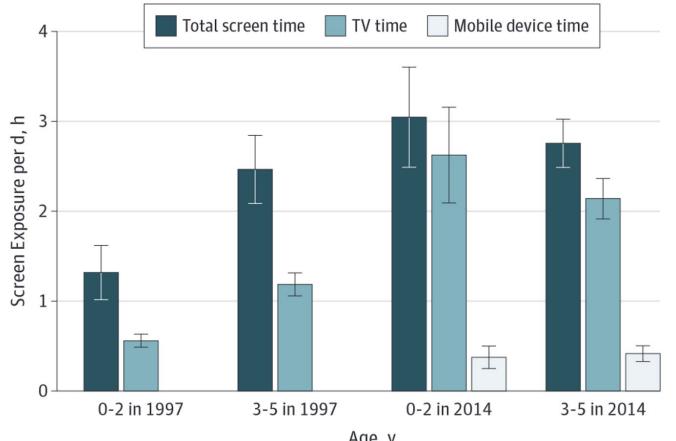
Methods

Results

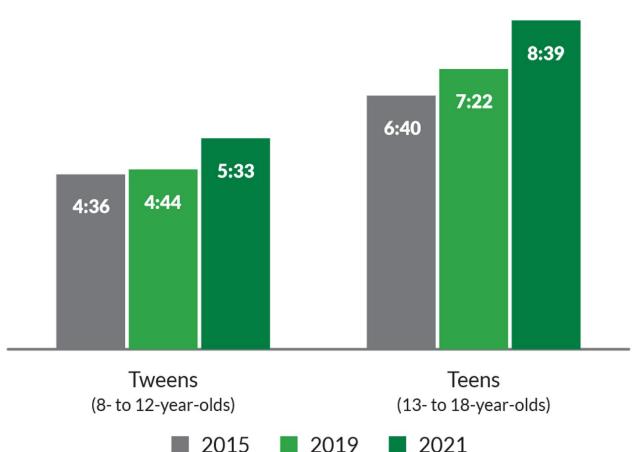
Discussion

Summary

## Rapidly Increasing Screen Time



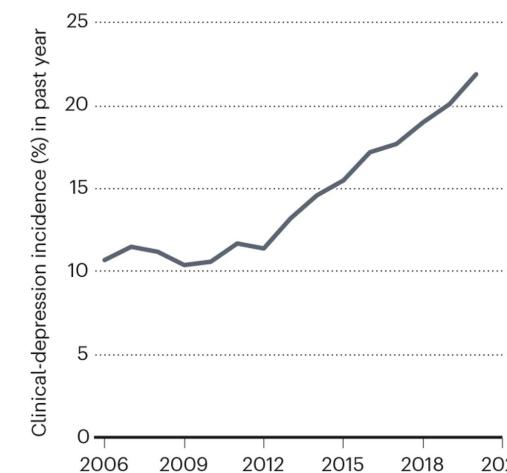
(Chen & Adler, *JAMA Pediatrics*, 2019)



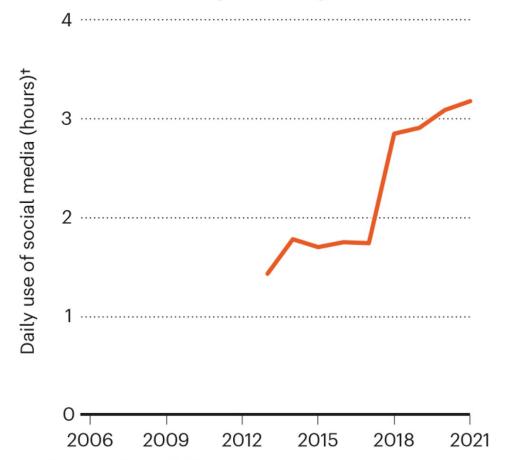
(Victoria et al., *Common Sense Media*, 2021)

## Troubling Trends: Youths' Mental Health

### Depression in 16-17-year-olds in the United States



### Social-media use by US 12th graders\*

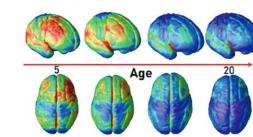


\* Students typically aged 17–18.  
† Starting in 2018, participants were asked to indicate their social-media use per day, rather than per week (as they had been asked previously).

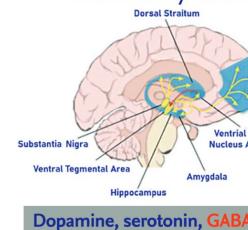
(Orben & Blakemore, *Nature*, 2023)

## Concerns: the developing brain

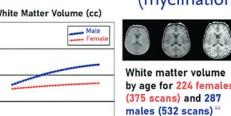
### Gray matter development



### Reward system



### White matter development (myelination)



### Digital media

(Giedd, *Dialogues Clin Neurosci*, 2020)



Peer/social connection  
Novelty/adventure  
Choices/selections  
Immediate/individualized  
Low failure cost  
Virtual arena for drives of sex/aggression



# Screen and Youths: What do we know?

Introduction

Methods

Results

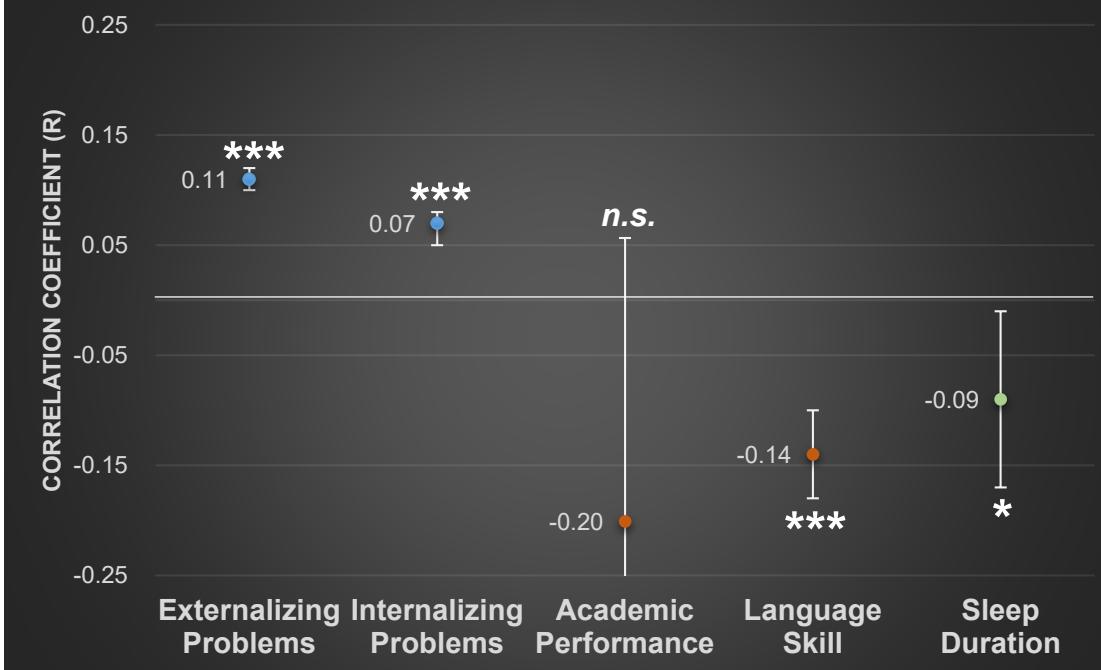
Discussion

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## Overall Screen Time

### Potential Side Effects on Youth Development

Aversive Associations with Behavioral Developmental Measures

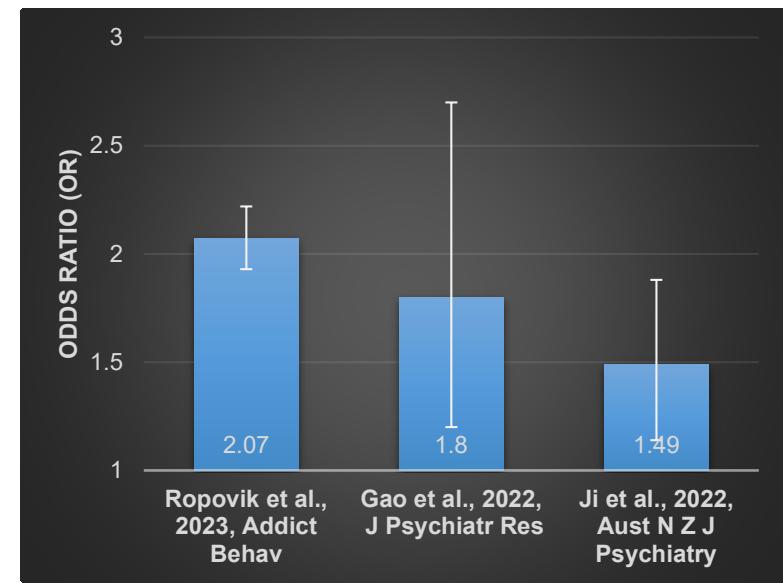


*small but significant*

### Risky Factor in Behavioral Addiction

Predicting Problematic Usage of Internet

e.g. (Internet) Gaming Disorder



*more use, more risk*



# What have not been clearly clarified?

Introduction

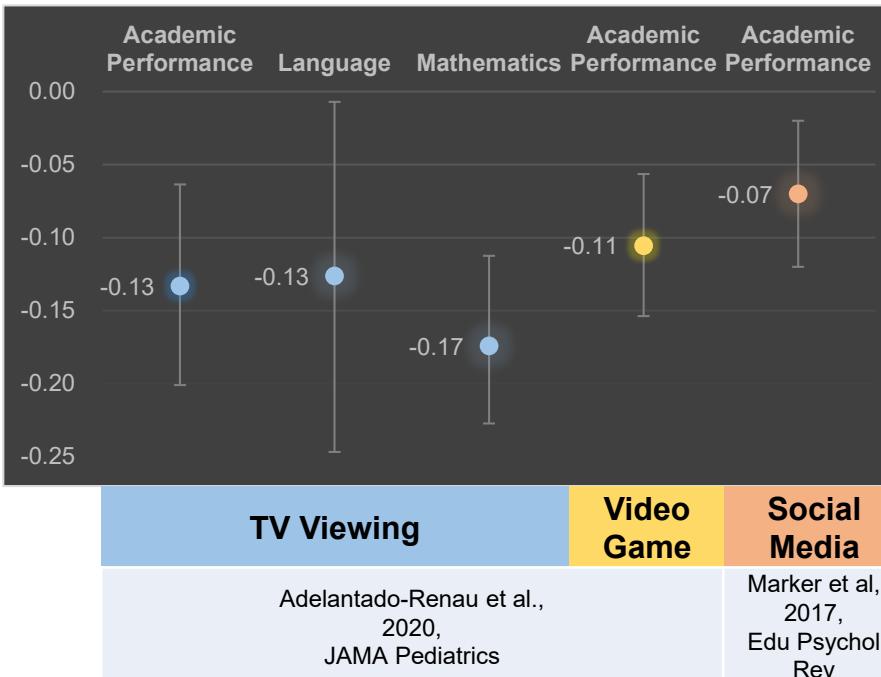
Methods

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## Heterogeneous Associations



**Usage type-specific effect?**

## Mixed Findings

EDITORIAL

Disentangling the Association of Screen Time With Developmental Outcomes and Well-being Problems, Challenges, and Opportunities

Janis Whitlock, PhD, MPH; Philipp K. Maser, PhD

(*JAMA Pediatrics*, 2019)

Editorial

Social media, screen time, and young people's mental health

Child and Adolescent Mental Health

Child and Adolescent Mental Health 24, No. 3, 2019, pp. 203–204



doi:10.1111/camh.12346

(*The Lancet*, 2019)

Editorial: Screen time, social media and developing brains: a cause for good or corrupting young minds?

(*Child Adolesc Ment Health*, 2019)

Comment

Screen time in children and adolescents: is there evidence to guide parents and policy?



**Evidence-based suggestions?**

(Ashton & Beattie, *Lancet Child Adolesc Health*, 2019)



# Screen Media Activity

**Screen Media Activity (SMA):** an integrated concept beyond screen time

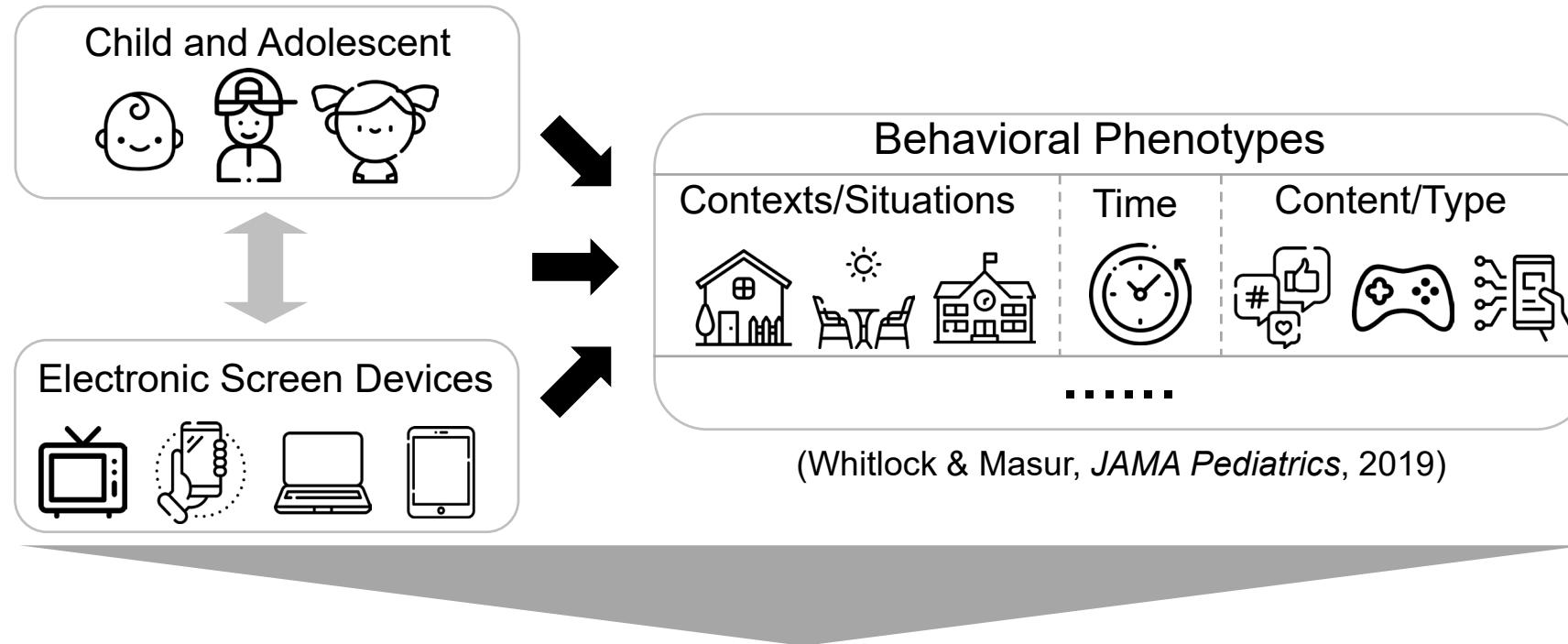
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Complex Screen-related Behaviors  
**Screen Media Activity**



# Where do we stand?

## Developmental Research Perspective

### Youth & SMA

Children and Adolescents



### Electronic Screen Devices



### What do we need?

### High-quality Empirical Evidences



Parents



Pediatricians



Teachers



Policy-makers

### What do we have?

### Mixed Findings



### What should we do?

**Disentangling** the mixed associations  
between SMA and youth development

*for real-world demand*

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# Where do we stand?

## Addiction Research Perspective

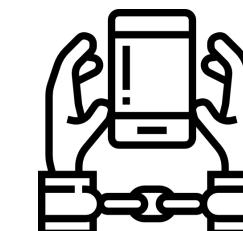
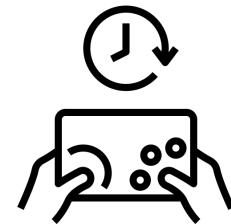
**Regular SMA**

Child and Adolescent



→ **Excessive SMA** → **Behavioral Addiction?**

Electroni Screen Devices



**Functional Impairments**

**What should we do?**

**Advancing the understanding of such behavioral dynamics  
Asking “why & how?” about emergence**

*for scientific research demand*

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# Research Questions

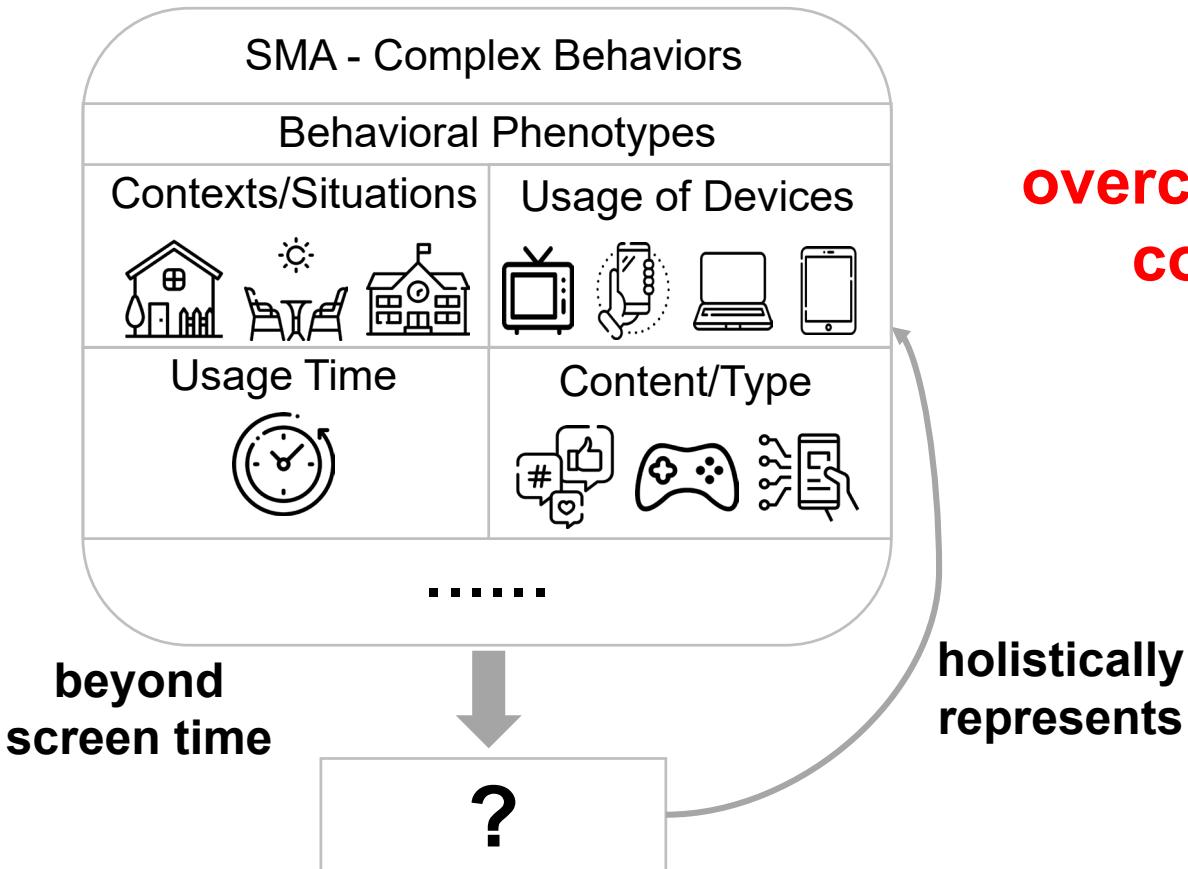
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**An Integrated Measure**

Quantifiable  
Replicable  
Interpretable

**overcome simplified measures  
considering complexity**



# Research Questions

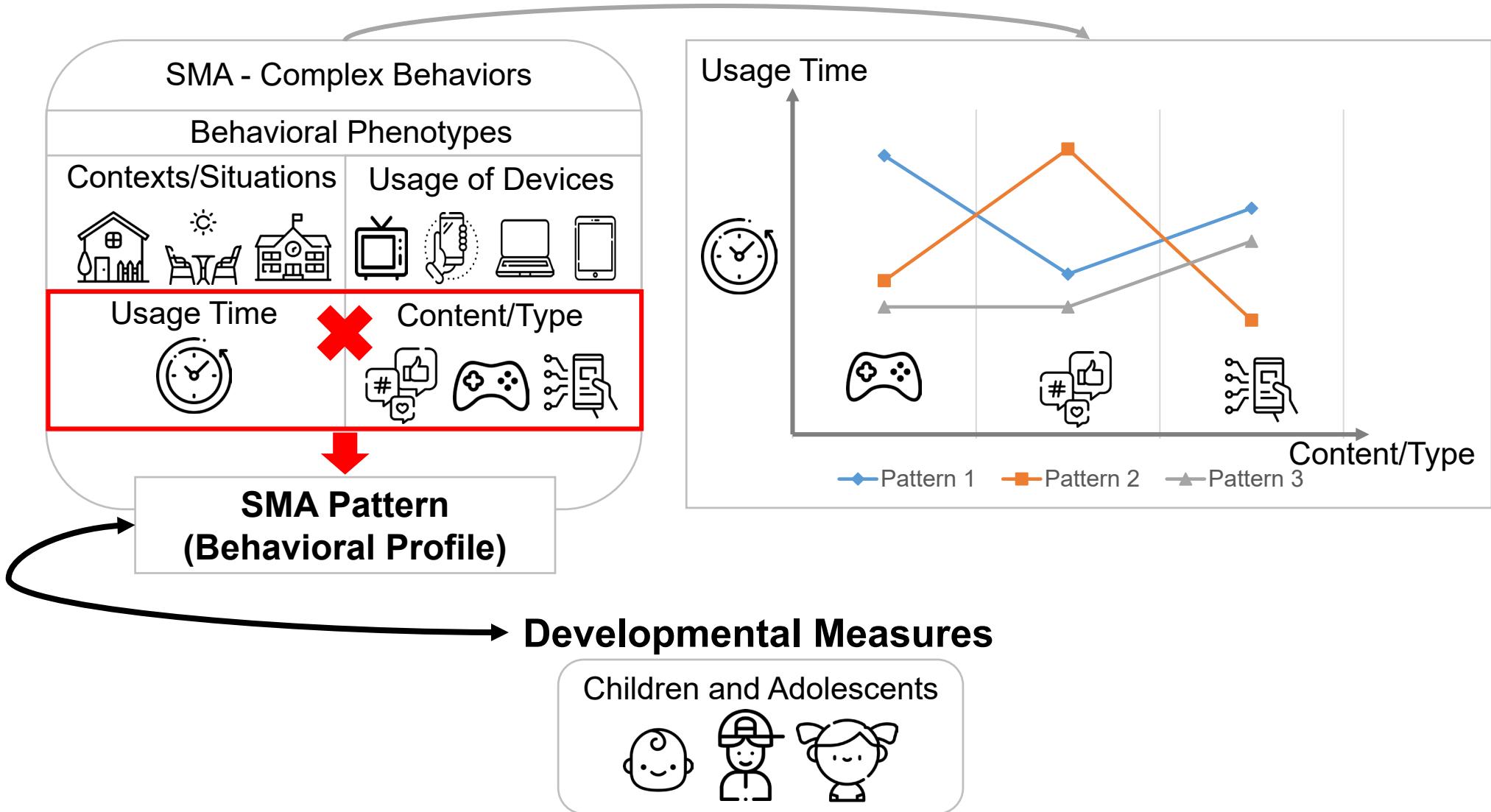
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# Present Study

Introduction

Methods

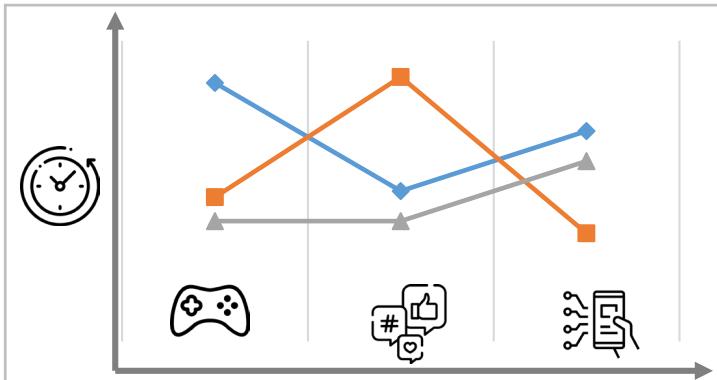
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## Aims

### 1. Identifying Youth SMA Patterns



- Reliable
- Robust
- Replicable
- Reproducible

## Hypothesis

Two Major SMA Patterns  
low-/high-frequency

### 2. Systematically Testing these Associations

#### Developmental Measures



- Neurocognition
- Mental Health
- Developing Brain

Poor Developmental Status  
in high-frequency

### 3. Longitudinally Investigating these Associations

Persist with age growing

*Preliminary and Exploratory*



# Study Design & Data

Introduction

Methods

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## Exploratory Analysis

The ABCD Study

N ≈ 11,000, age 9-10

multi-site (21) longitudinal cohort



Adolescent Brain Cognitive Development®

*Teen Brains. Today's Science. Brighter Future.*



**CONNECTOME**  
COORDINATION FACILITY

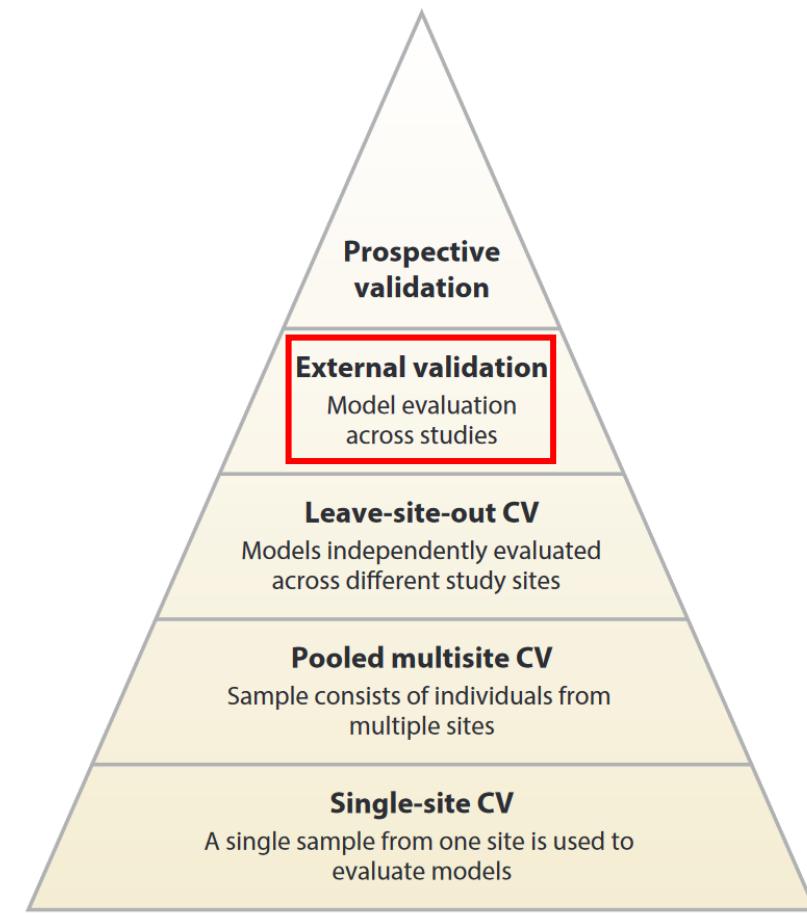
The HCP-D Study

N ≈ 650, age 5-21

four-site neuroimaging dataset

External Validation

Generalizability hierarchy



(Dwyer et al., *Annu Rev Clin Psychol*, 2018)



# Data Analysis

Introduction

Aims

Identifying SMA Pattern

Sample

ABCD 4.0 Release

Variables

Youth-reported SMA

Measures

Screen Time Questionnaire

Generalizability Examination

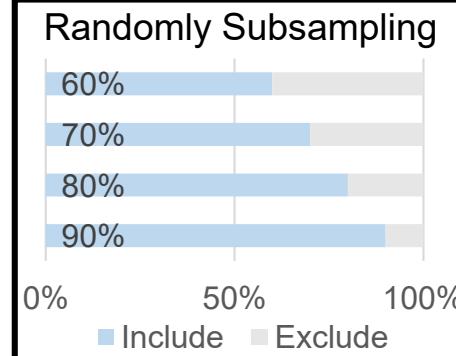
Comparing the identified SMA Patterns & Evaluating Replicability

HCP-D 2.0 Release



identified Individual SMA Patterns

ABCD 4.0 Release  
HCP-D 2.0 Release

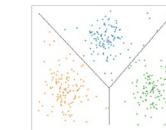


500 Repetitions

Clustering Analysis

Statistical Analysis

Primary



K-means

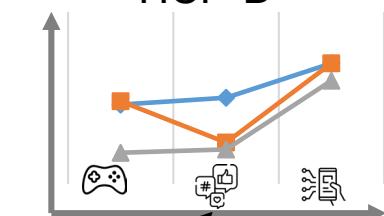
Sensitivity

- Subsampling
- Reassignment Analysis
- Hierarchical Clustering
- Latent Profile Analysis

ABCD



HCP-D



Representational Similarity Analysis

$$SQD = \sum_{j=1}^p (c_{1,j} - c_{2,j})^2$$

$$SQD_i = \sum_{j=1}^p (c_{i,j} - c_{1,j})^2$$



# Data Analysis

## Introduction

Aims	Sample	Variables	Measures	Primary	Sensitivity
Testing the hypothesized Associations (Cross-sectional)	ABCD 4.0 Release (Baseline Wave) 	IV SMA Patterns DV Neurocognitive Ability Individual Trait Behavioral Problems Psychotic-like Experience	Dummy-coded The NIH Toolbox BIS/BAS UPPS-P CBCL PPS	Mixed Effect Modeling 	Population Weighting
Investigating the hypothesized Longitudinal Effects	ABCD 4.0 Release (Follow-up Waves) 			Multiple Comparison Correction (FDR) 	Covariates Adjustment

## Exploratory Analysis

## Discussion

	DV Developing Brain Functions SMA Pattern Transition	Resting-state Functional Network Connectivity	Mixed Effect Modeling  Step-wise Modelling
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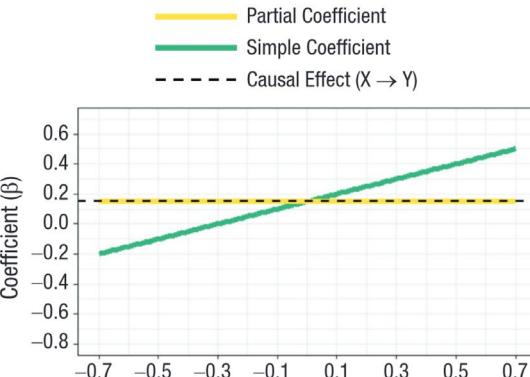
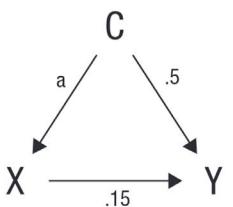
## Summary



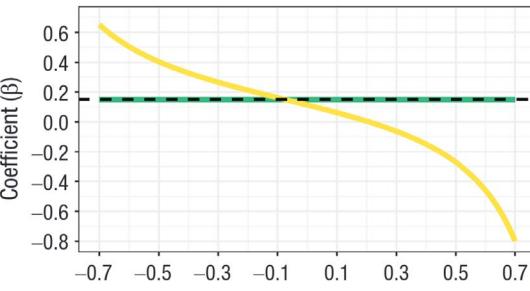
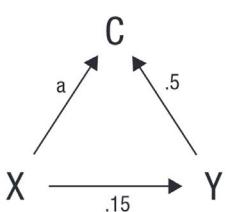
# Covariates Adjusting

## Illustrations about Type of Covariate

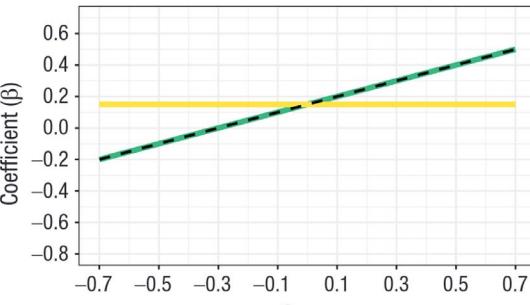
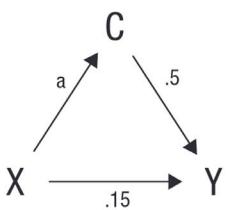
### Confounder



### Collider

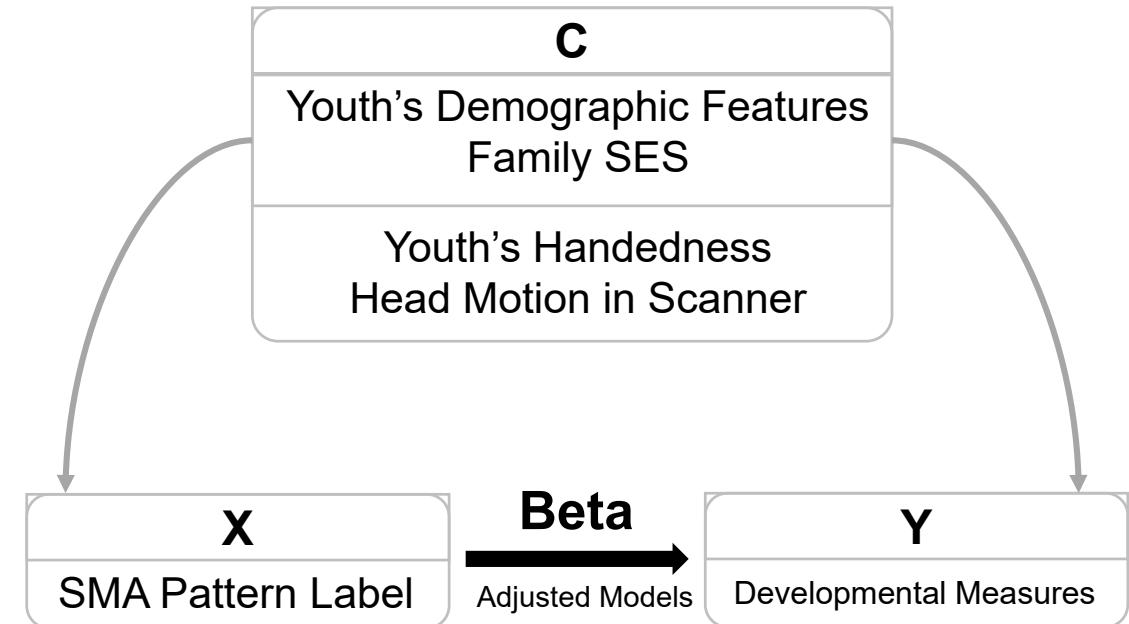


### Mediator



(Wysocki et al., *Adv Meth Pract Psych*, 2022)

## In our analysis



## Hypothesized Associations

### Causal Justifications

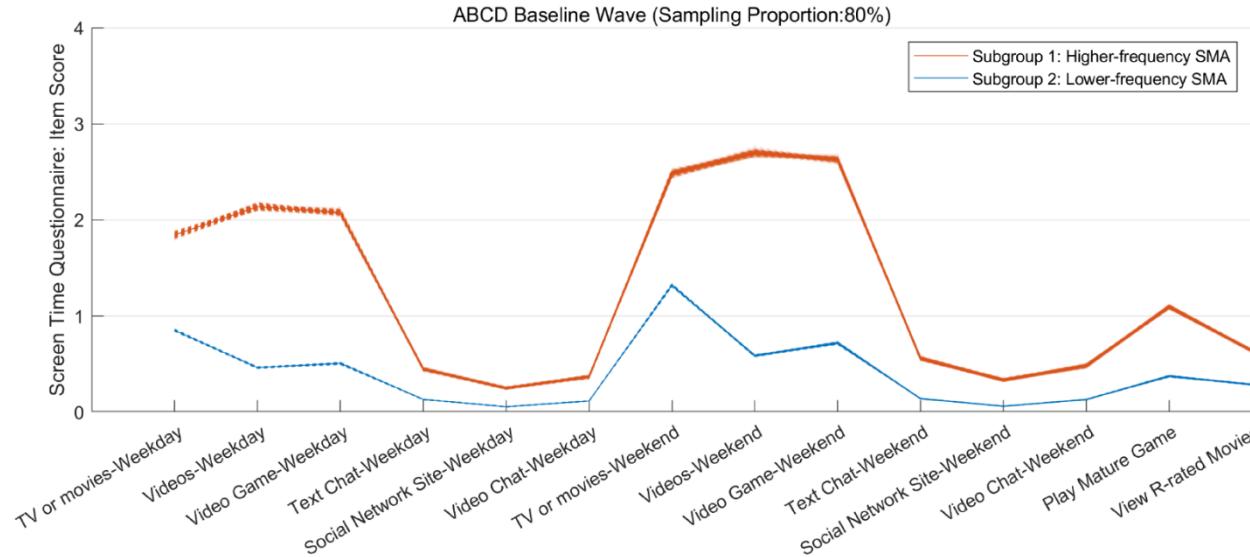
- logically justifying
- theory-driven
- empirical evidence-based



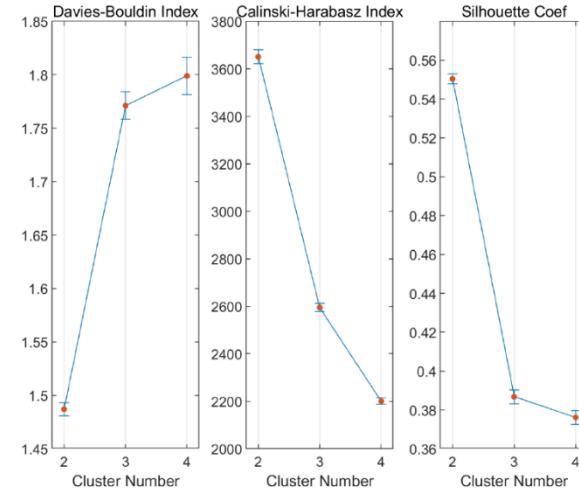
# Identified SMA Patterns

**Figure 1 A&B**

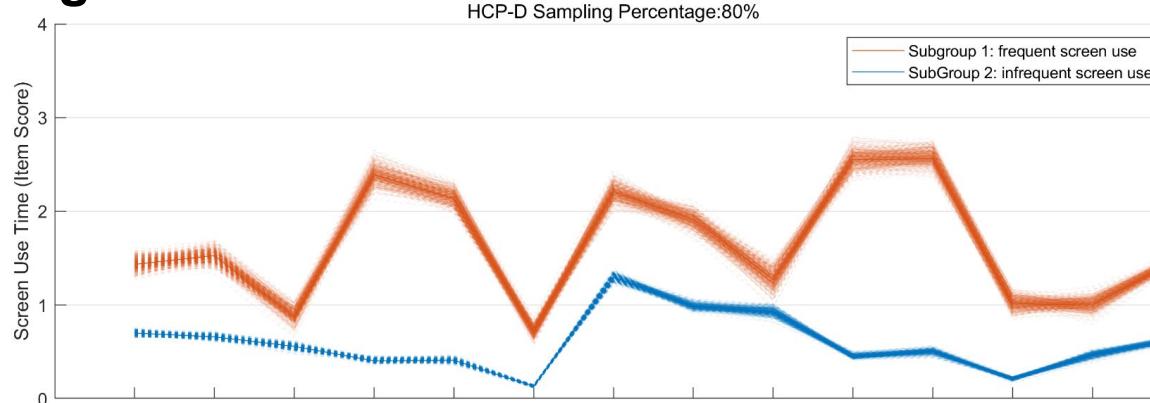
**A. Screen Media Activities Patterns Identified in ABCD Baseline Wave**



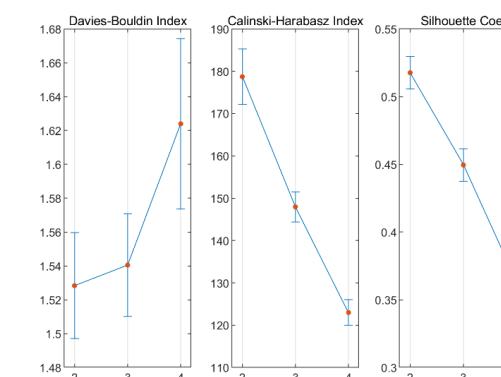
**B. Cluster Evaluations**



**Figure S8. C Not Successfully Replicated in HCP-D (age 5-21)**



HCP-D Sampling Percentage: 80%





# Identified SMA Patterns

Introduction

Methods

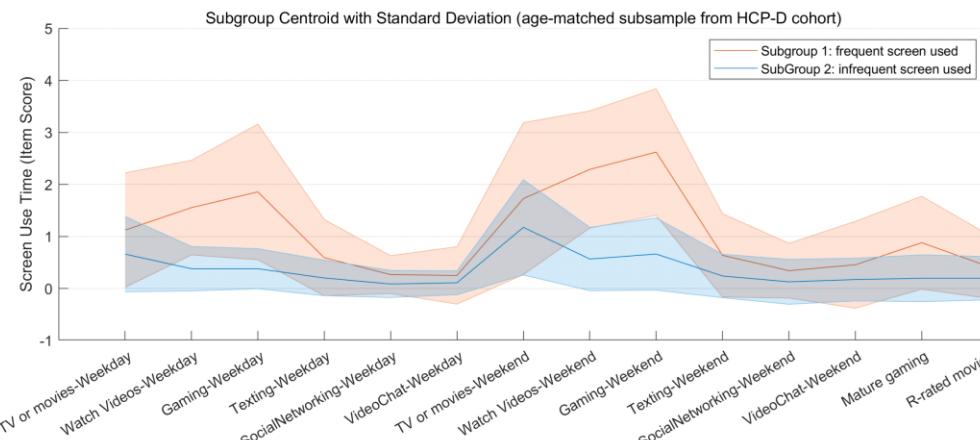
Results

Discussion

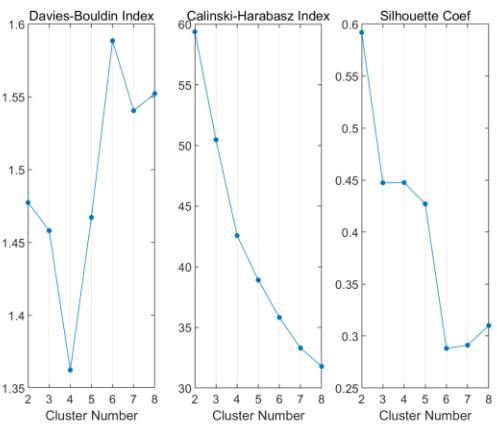
Summary

**Figure S7** Age-dependent Patterns?

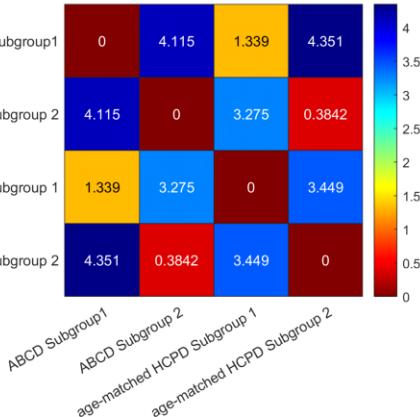
A. Cluster Centroids for HCP-D age-matched subsample (N=116, 9-10 years of age)



B. Cluster Evaluations

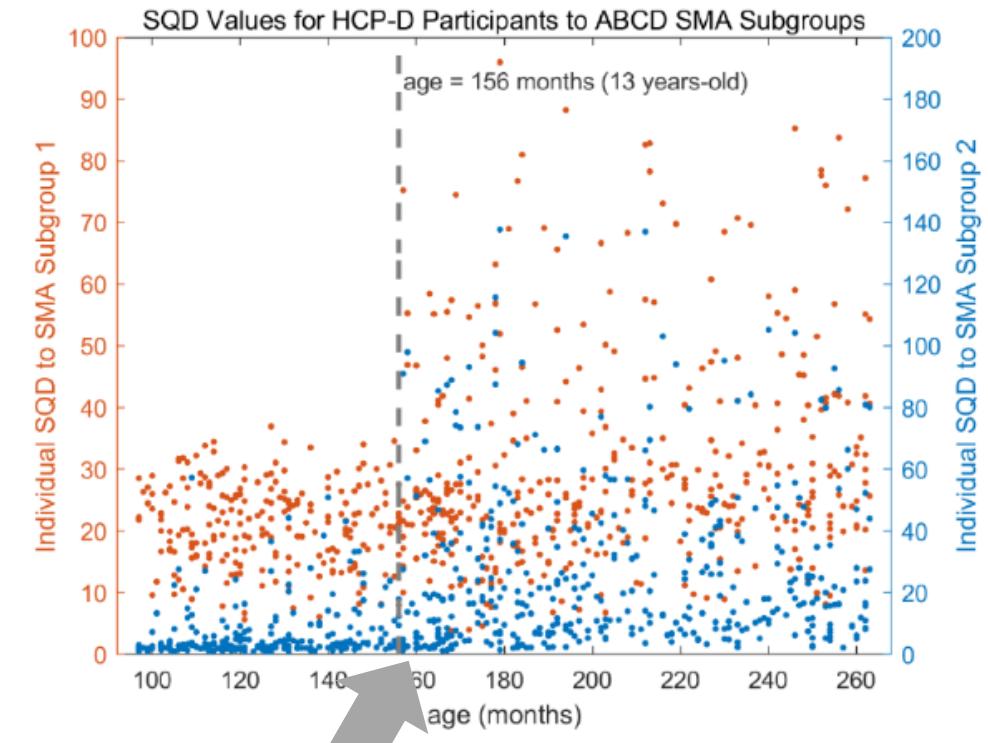


C. Cluster Centroids Compared with ABCD baseline



**Figure 1. D**

**D. SQD Values: Individuals (HCP-D)**



a noticeable cliff



# Identified SMA Patterns

Introduction

Methods

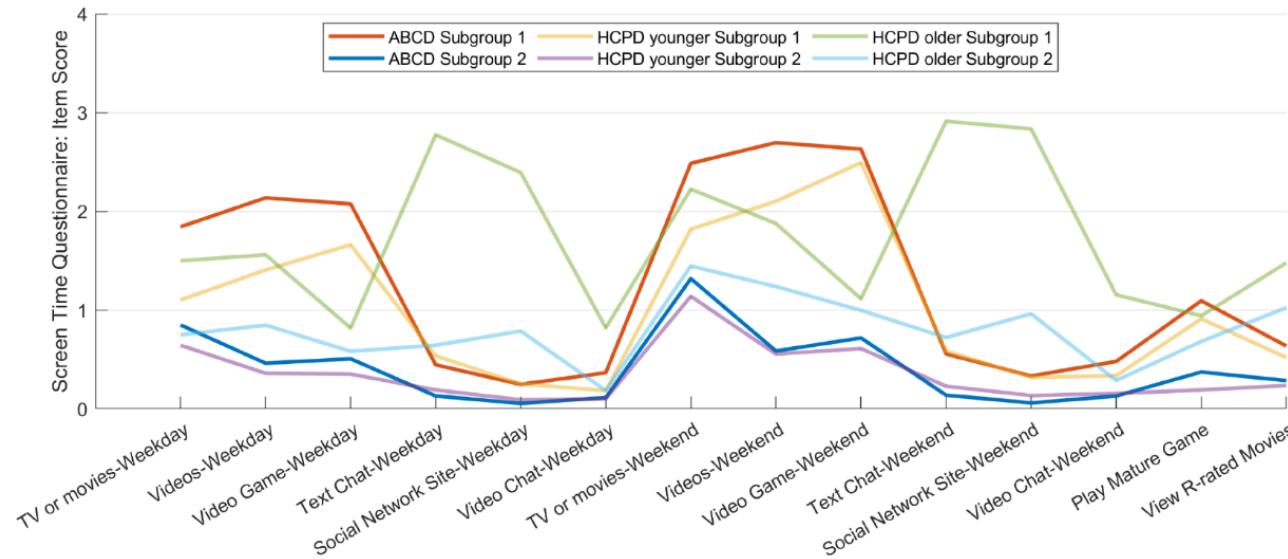
Results

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**Figure 1. C**

C. SMA Patterns Comparison: ABCD Baseline Versus HCP-D



**Figure S9. A**

A Similarity between ABCD baseline and HCPD

	ABCD Subgroup1	4.115	1.476	4.407	5.319	3.478
ABCD Subgroup 2	4.115	0	2.975	0.42	5.959	1.82
HCPD younger Subgroup 1	1.476	2.975	0	3.219	5.131	2.4
HCPD younger Subgroup 2	4.407	0.42	3.219	0	5.97	1.875
HCPD older Subgroup 1	5.319	5.959	5.131	5.97	0	4.358
HCPD older Subgroup 2	3.478	1.82	2.4	1.875	4.358	0

ABCD Subgroup1  
ABCD Subgroup 2  
HCPD younger Subgroup 1  
HCPD younger Subgroup 2  
HCPD older Subgroup 1  
HCPD older Subgroup 2

Generalizability Examination: Partially Passed ✓

Two SMA Patterns on SMA usage magnitude  
**before puberty!**



# SMA Patterns: Sociodemographic Features

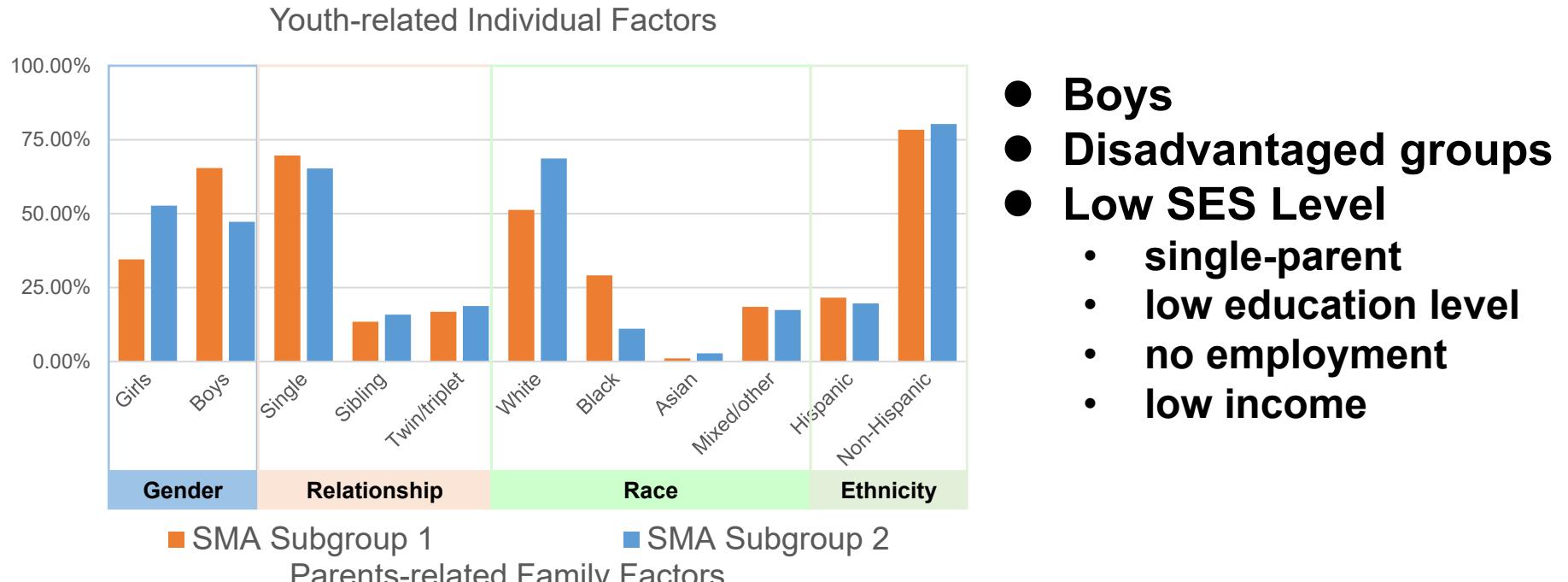
Introduction

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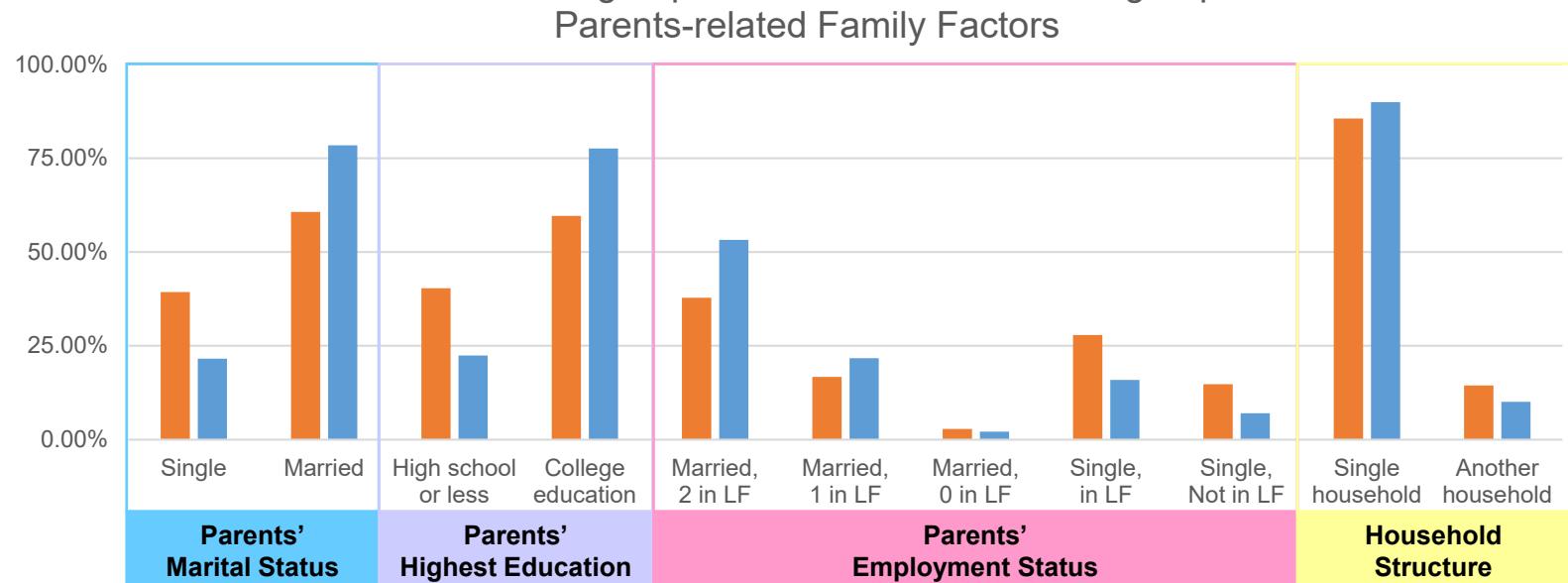
Results

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Summary



- Boys
- Disadvantaged groups
- Low SES Level
  - single-parent
  - low education level
  - no employment
  - low income





# Cross-sectional Findings

**Figure 2 A&B**

Introduction

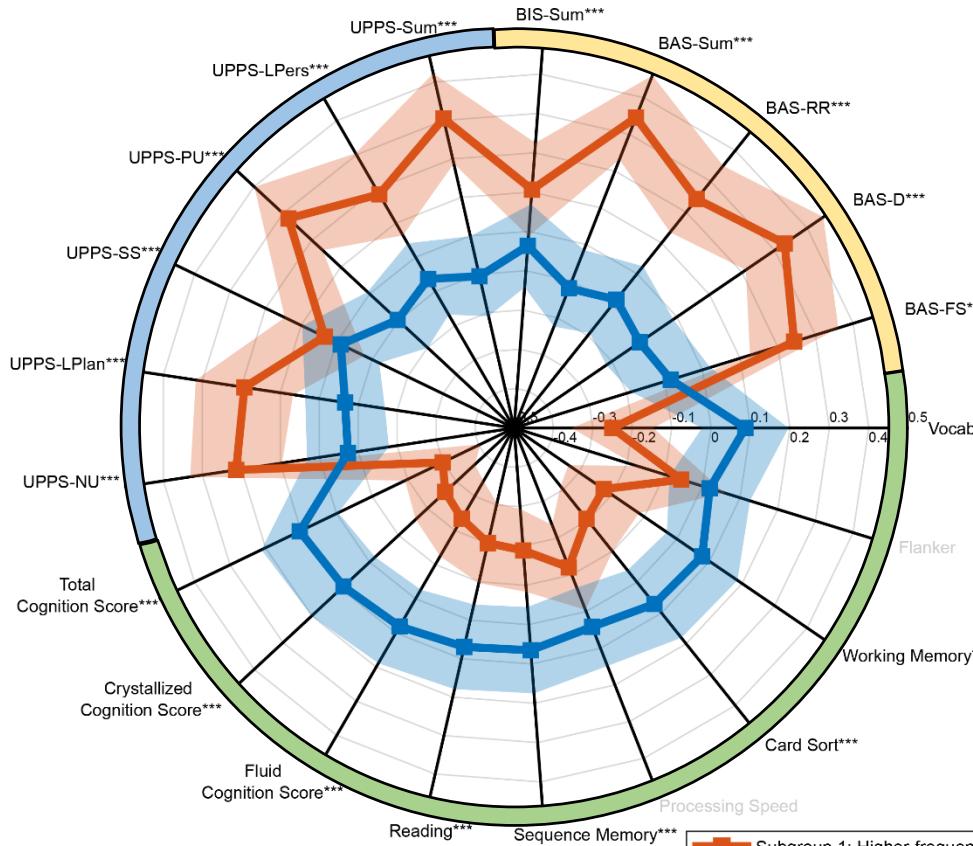
Methods

Results

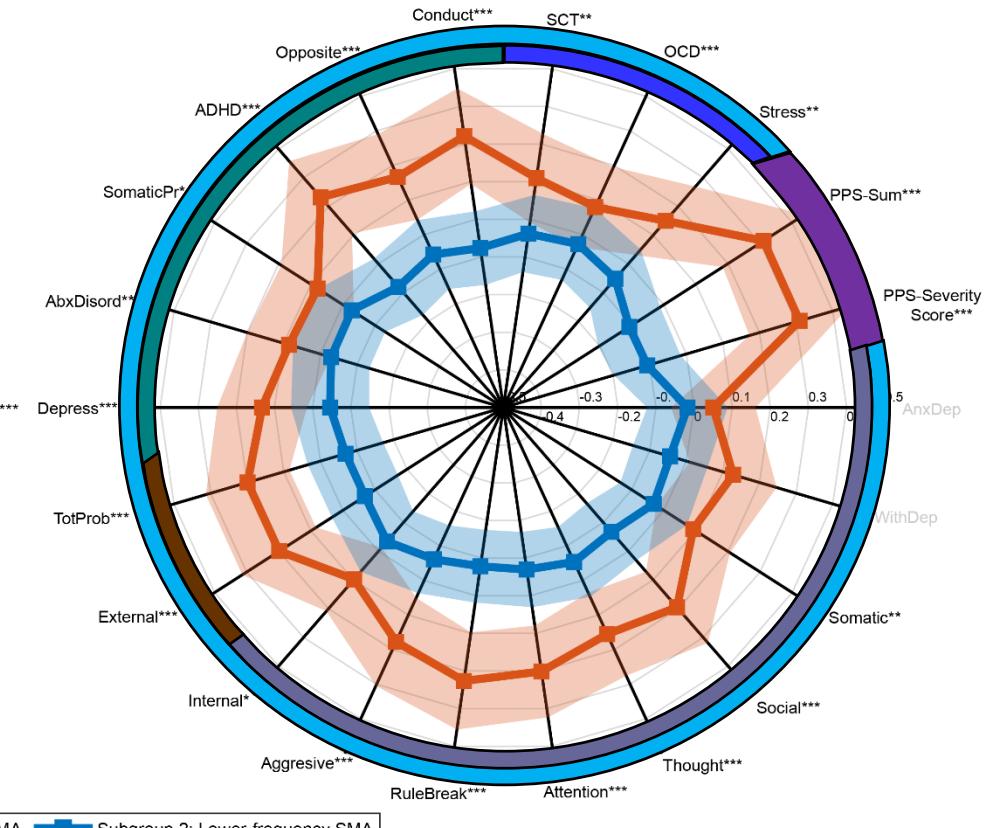
Discussion

Summary

**A. SMA Subgroup Differences: Neurocognition**



**B. SMA Subgroup Differences: Mental Health**



Impulsivity      Cognitive Performance      Sensitivity to Reward/Punish



Behavioral Problem		Psychotic-like Experience	
2007 Scale	DSM-5-Oriented	Composite Score	Syndrome Score



# Cross-sectional Findings

Figure 2 C&D

Introduction

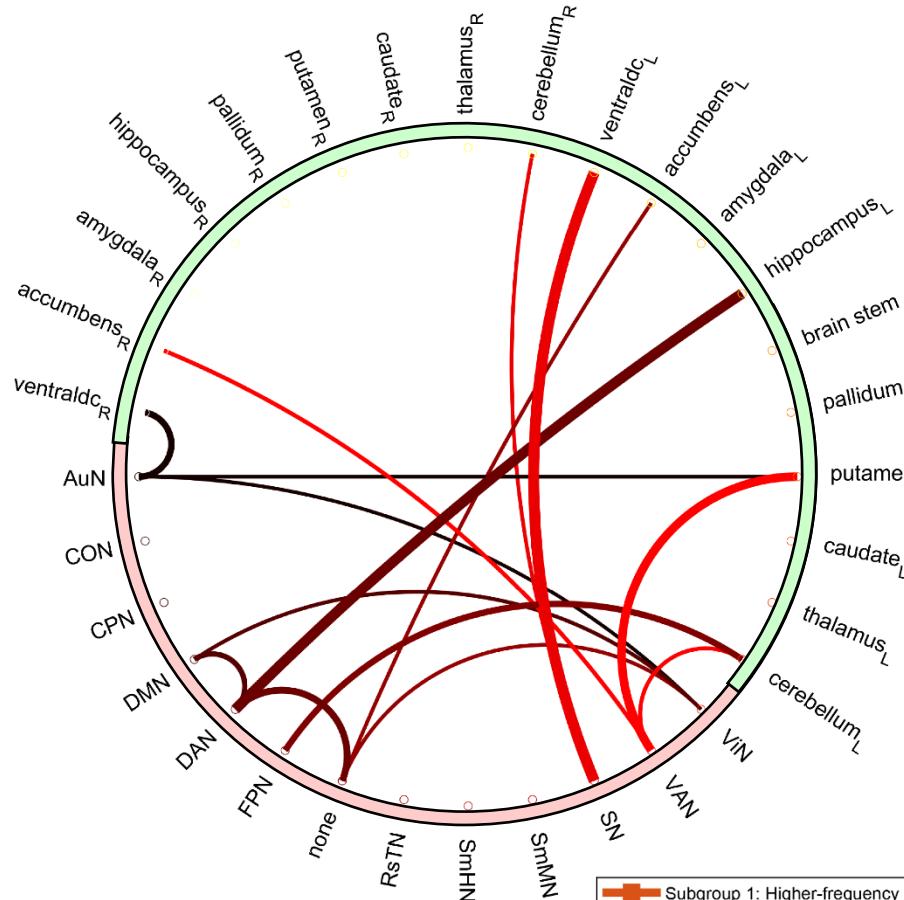
Methods

Results

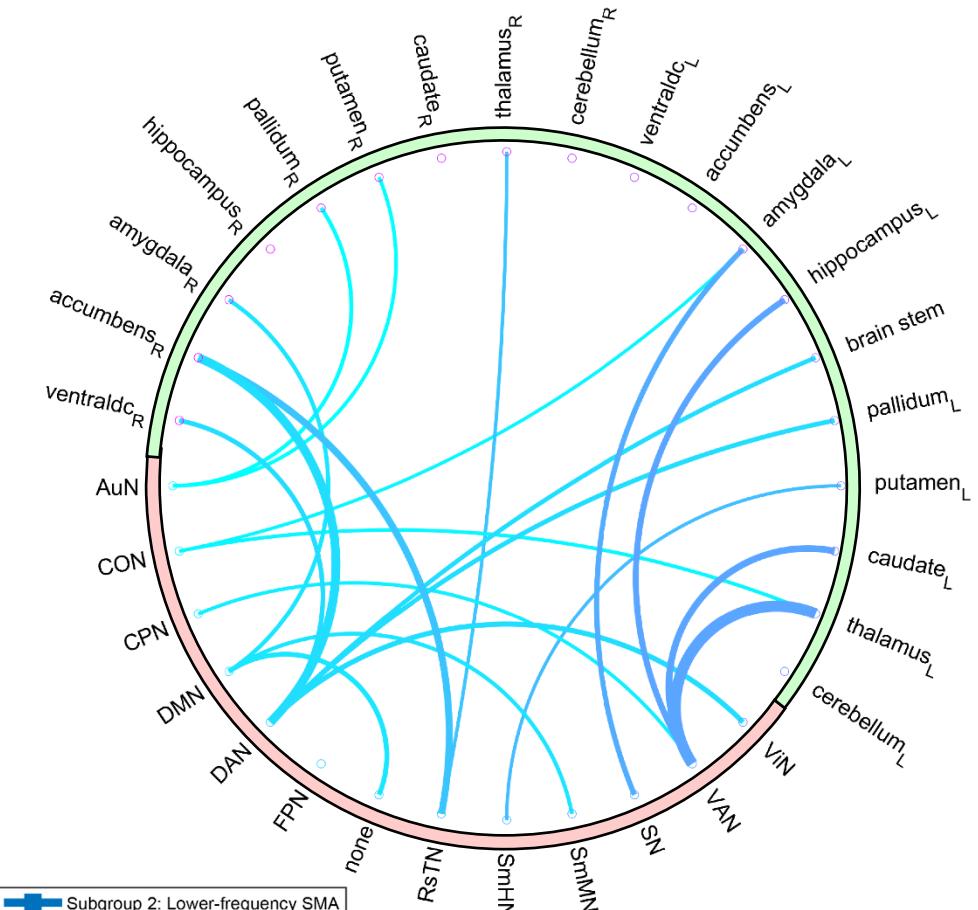
Discussion

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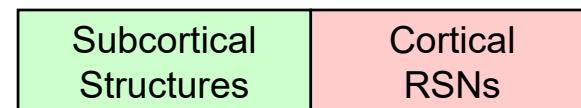
C. SMA Subgroup Differences: RSFC Positive Network



D. SMA Subgroup Differences: RSFC Negative Network



- Reward Responsiveness
- Audio-visual Functions
- Language Skills



- Attention Processing
- Emotion Regulation
- Goal-directed Control



# Longitudinal Findings

Introduction

Methods

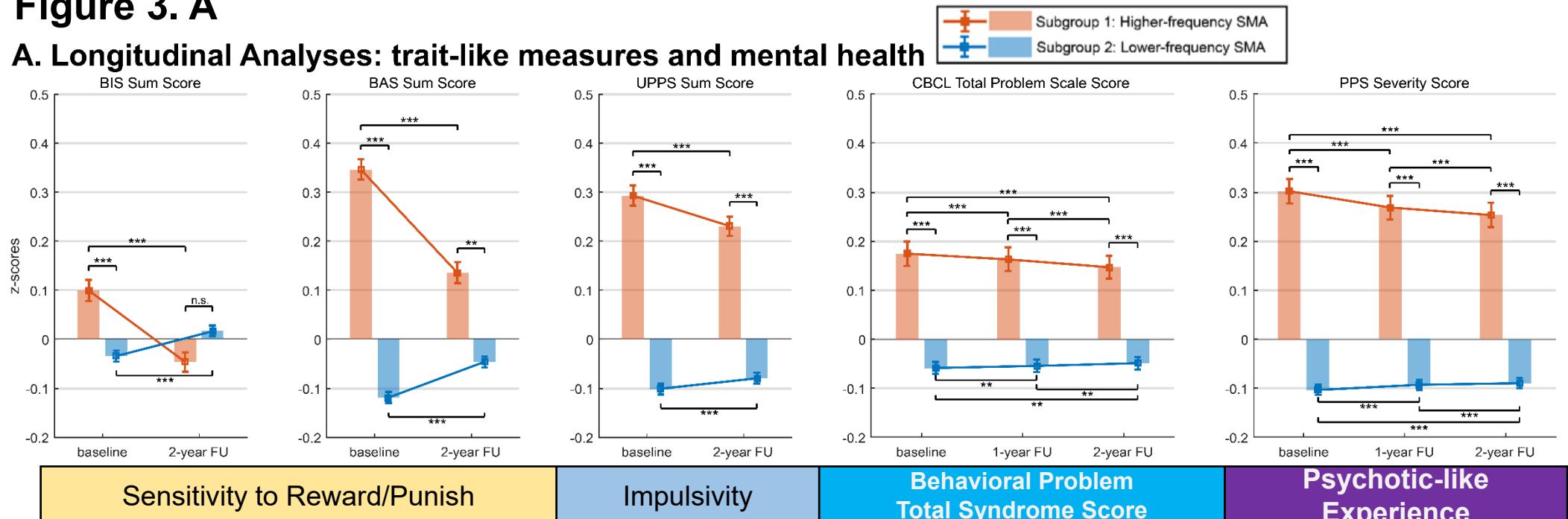
Results

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**Figure 3. A**

## A. Longitudinal Analyses: trait-like measures and mental health



**Differences Persist With Age Increasing:**

- Higher Sensitivity to Reward
- Higher Impulsivity
- More Total Behavioral Problems
- More Psychotic-like Experience



# Longitudinal Findings

Introduction

Methods

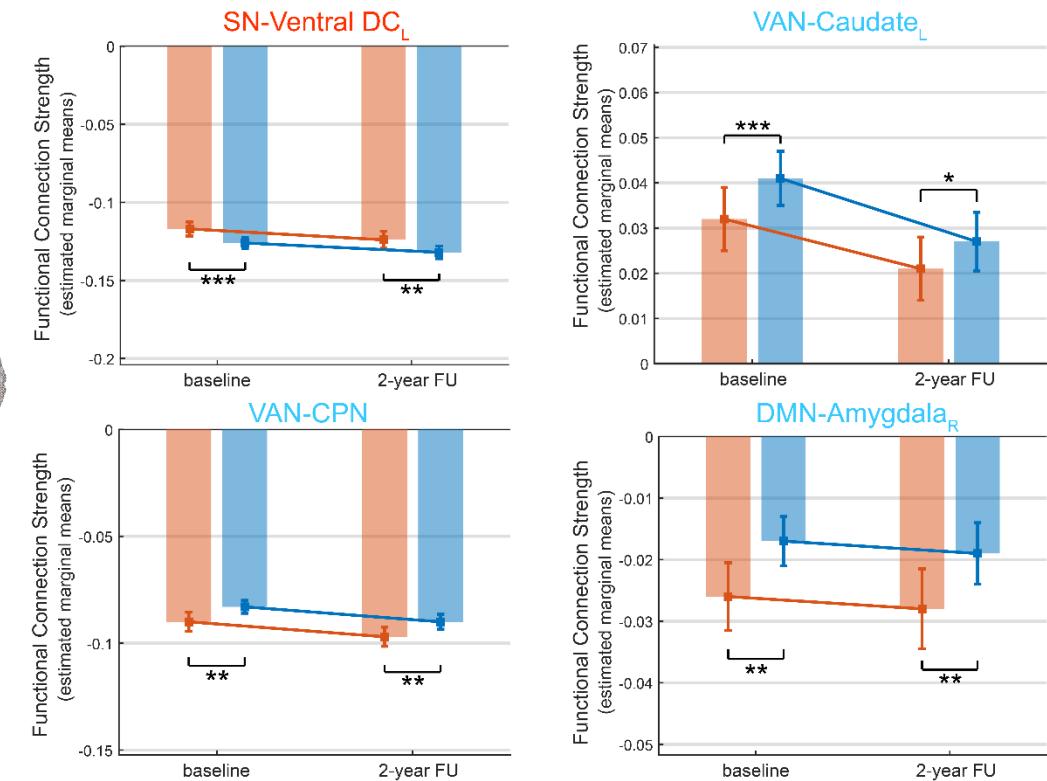
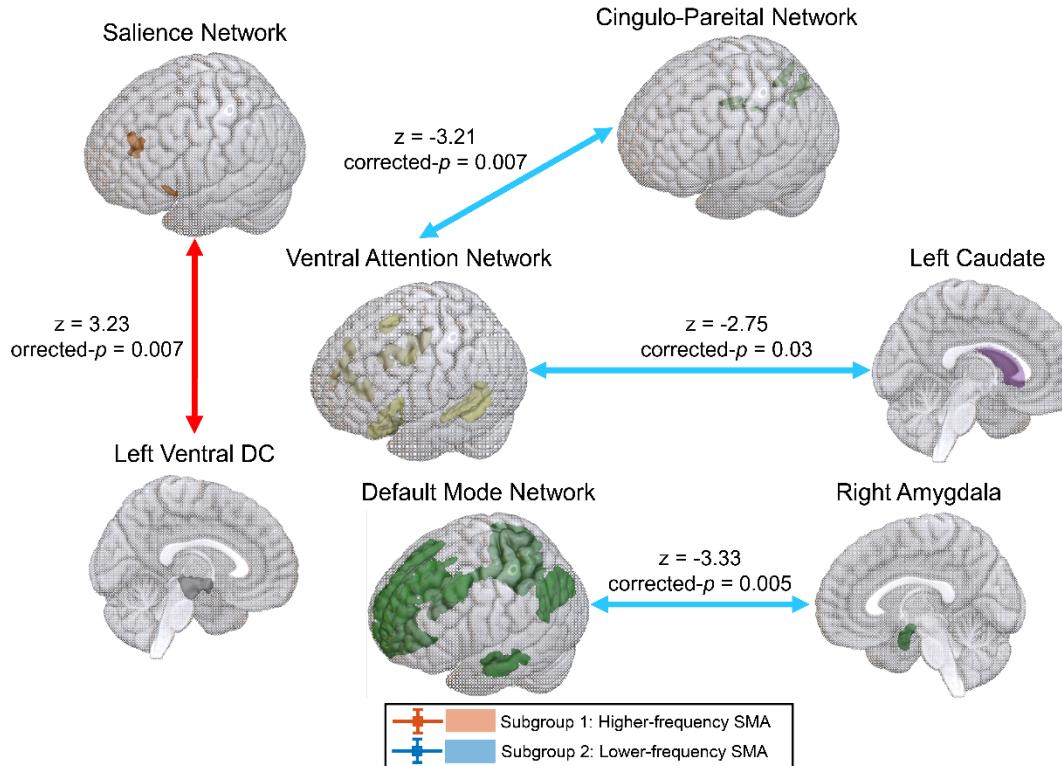
Results

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Figure 3. D

## D. Longitudinal Analyses: resting-state brain functional connection



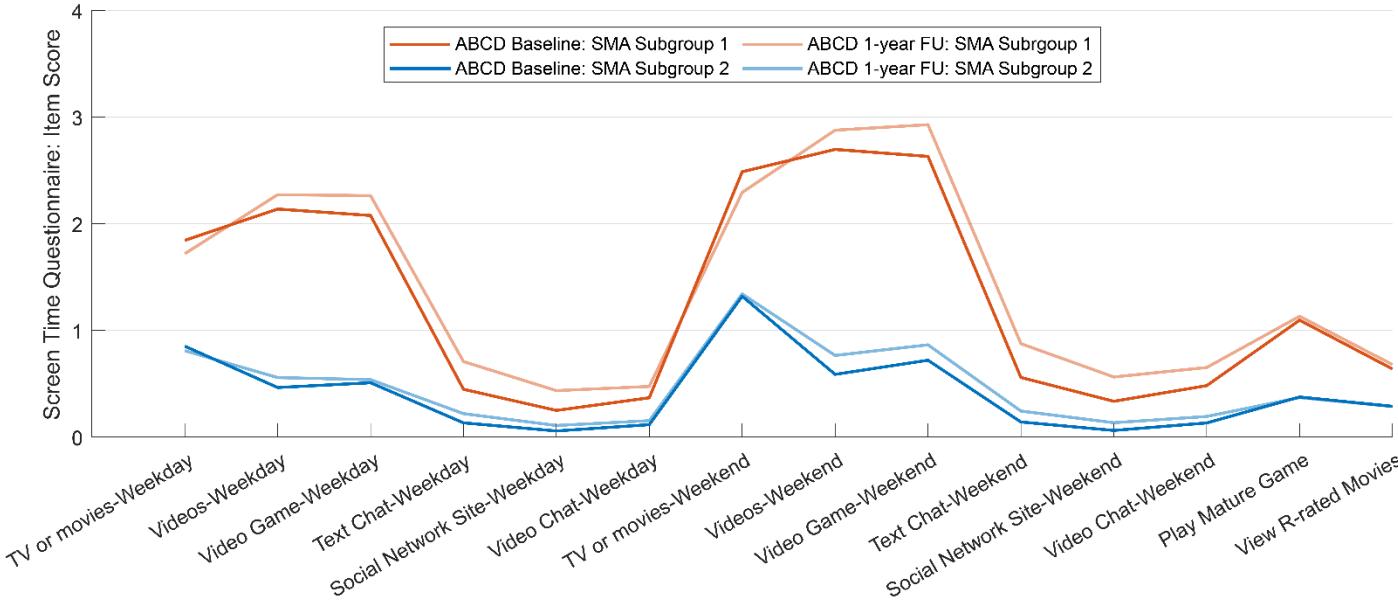
- **SN-left Ventral DC:** Reward Responsiveness and Motivational Salience
- **CON-VAN:** Sustained Top-down, Goal-directed Control
- **VAN-left Caudate:** Attention Resource Allocation and Attention Processing
- **DMN-right Amygdala:** Interoceptive Sensibility and Affect Processing



# Longitudinal Findings

**Figure 3. B&C**

**B. Re-identification of SMA patterns after 1-year follow-up**



**C. SMA Pattern Transition Matrix**

		1-year FU Wave	
		Subgroup 1	Subgroup 2
Baseline Wave	Subgroup 1	1868 (16.79%)	1046 (9.40%)
	Subgroup 2	1510 (13.57%)	6071 (60.23%)
		3378 (30.36%)	7747 (69.64%)

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# Current Findings

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## Summary

- Low-/High-frequency SMA Patterns are predominated before puberty
- For **High-frequency SMA**:
  - **higher** impulsivity, **higher** sensitivity to reward (& punishment)
  - **More** behavioral problems, more psychotic-like experiences
  - **Poorer** Cognitive Performance
  - **Altered** RSFC in Developing Brain
  - **Small to Medium** Effect Sizes
- Age increased - **More High-frequency SMA** individuals emerged  
  
**Small to Medium, but Significant Effect Size**



# Limitations & Future Directions

Introduction

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## 1. Causality is Important

- Instrumental Variable (Mendelian randomization)
- Prospective Design

## 2. Dynamics in SMA Pattern Transition

- Multi-state Markov Chain Modelling
- Bi-directionality Testing (e.g. RI-CLPM)

## 3. Objective and Accurate Measures on SMA

- passive-sensing; experience sampling method

## 4. Appropriately Interpret Findings in Neuroimaging

- Contextual-based Analysis; More Empirical Evidence;

## 5. Uncovering Its Relationships with Behavioral Addiction

- Possible Precursor? State or Stage in Addiction Progress/Dynamics?



# Implications

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- ◆ **Video-centric SMA** in aged below 13 years
  - on average, time spent above 2 hours per day
  - more clinical concerns
  - possibly disturb youth development
  - potential needs for early-intervention
- ◆ Video/Social-centric SMA **bifurcation**
  - age-dependent effects
  - developmentally sensitive associations?
- ◆ Video-centric High-frequency SMA **increasing with age growing**
  - timing for prevention/early-intervention
  - adolescent period
- ◆ SMA Pattern & (Online) **Behavioral Addiction**
  - Similar group differences in neuro-behavioral measures
  - boundary? transition? emergence?



# Thank You!

Email: songkunru@mail.bnu.edu.cn



State Key Laboratory of Cognitive Neuroscience  
and Learning, Beijing Normal University

**Github:** <https://github.com/fenmeng123> Analysis Codes & Slides are publicly available on Github!

**Researchgate:** <https://www.researchgate.net/profile/Kunru-Song>



Kunru Song

Bachelor of Engineering · PhD Student

**Institution and department**

Beijing Normal University · State Key Laboratory of Cognitive Neuroscience and Learning

**Skills**

Adolescent Development · Machine Learning · fMRI + 7 others

KunruSong

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