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Phenotyping Environment-PA Dynamics in Youth During Summer

A Multilevel Dynamic Structural Equation Modeling Approach

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Summer disrupts youth physical activity

74%

of adolescents fail to meet recommended physical activity levels



Summer

Structured school supports and peer networks disappear



The Gap

Little is known about how individual youth respond to their everyday environments

Understanding individual differences could power just-in-time interventions for the kids who need them most.

Two environments shape youth physical activity

Social Environment

- Emotional closeness (bonding)
- Perceived PA norms among peers
- Susceptibility to social influence

Built Environment

- Perceived safety of surroundings
- Pleasantness of the environment
- Availability of space to be active

But how youth respond to these environments varies dramatically person to person.



Our research question

Can we identify *preliminary* phenotypes that capture how individual youth respond to their everyday social and built environments?

Intensive longitudinal data from 36 youth

36

Youth participants

Aged 11 to 15, Central Texas

7

Days of data per youth

Summer 2025: May to July

6×

EMA prompts per day

Smartphone-delivered

1,260

Within-day observations

Plus continuous accelerometer

- Each prompt captured current social context (closeness, norms, influence), built environment perception (safety, space, pleasantness), and momentary activity.
- Accelerometer-derived MVPA in the next 30 minutes served as the prospective outcome.

A three-step analytical pipeline

1

Multilevel DSEM

Modeled temporal links between environment perceptions and MVPA in the next 30 minutes, nesting prompts within days within youth.

2

Person-Specific Coefficients

Extracted each youth's own environment-PA correlation coefficients to capture individual responsiveness patterns.

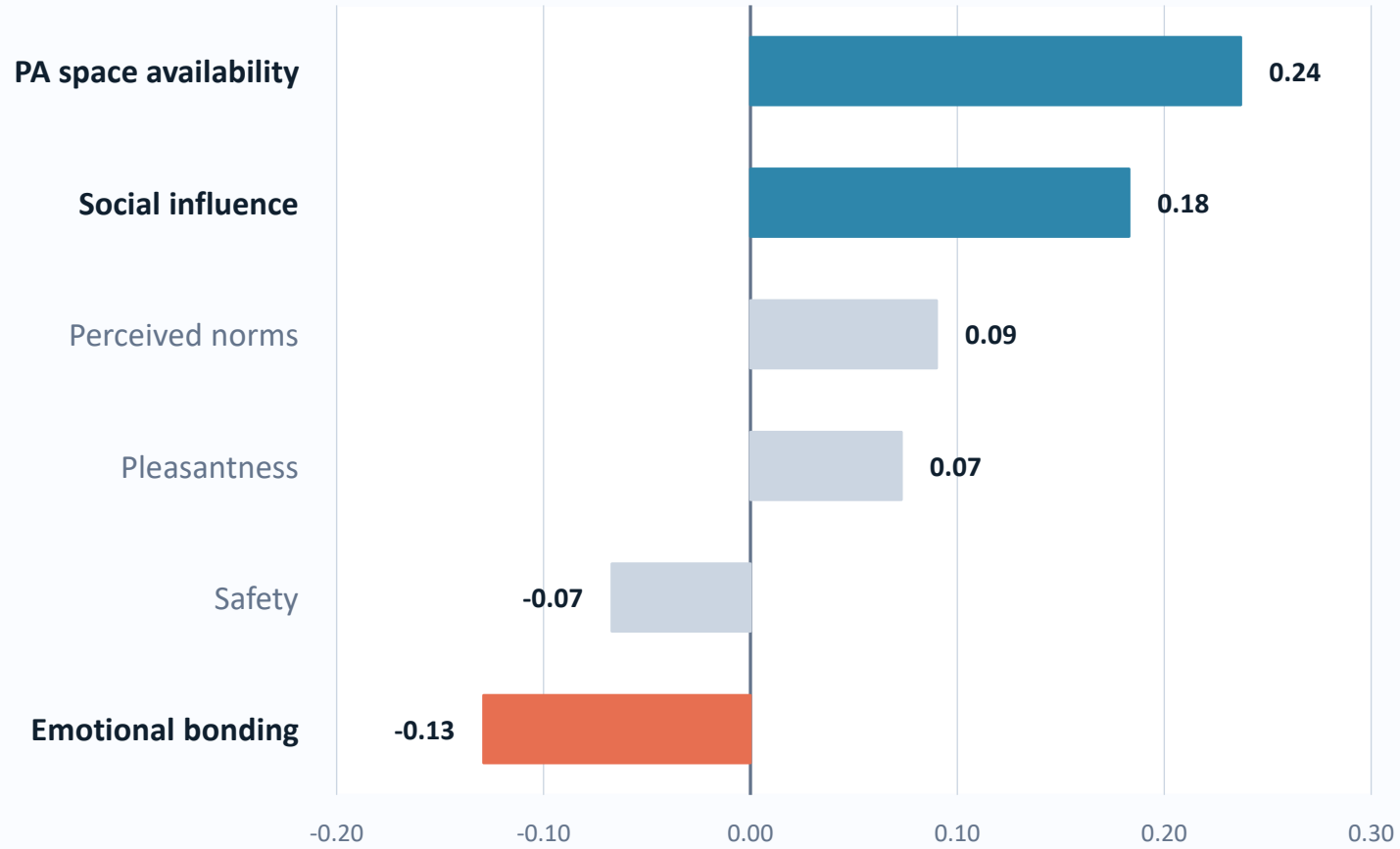
3

Hierarchical Clustering

Used Ward's method on person-specific coefficients to identify distinct digital phenotypes.

This pipeline is meant to preserve the temporal structure of EMA data while surfacing how each individual responds differently.

What predicts the next 30 minutes of MVPA?



PA space availability

β = 0.24

p < 0.001 • strongest built env effect

Social influence

β = 0.18

p < 0.01 • strongest social effect

Emotional bonding

β = −0.13

p < 0.05 • inverse association

Average effects mask substantial individual variation. That variation is the story.

Three preliminary phenotypes emerged

Built Environment Responsive

44%

of sample • n = 16

Strong reactivity to physical environmental cues. Activity rises when space, safety, and pleasantness are favorable.

Social Environment Responsive

42%

of sample • n = 15

Highly sensitive to peers and social network characteristics. Activity tracks norms, emotional closeness, and influence.

Environment Resistant

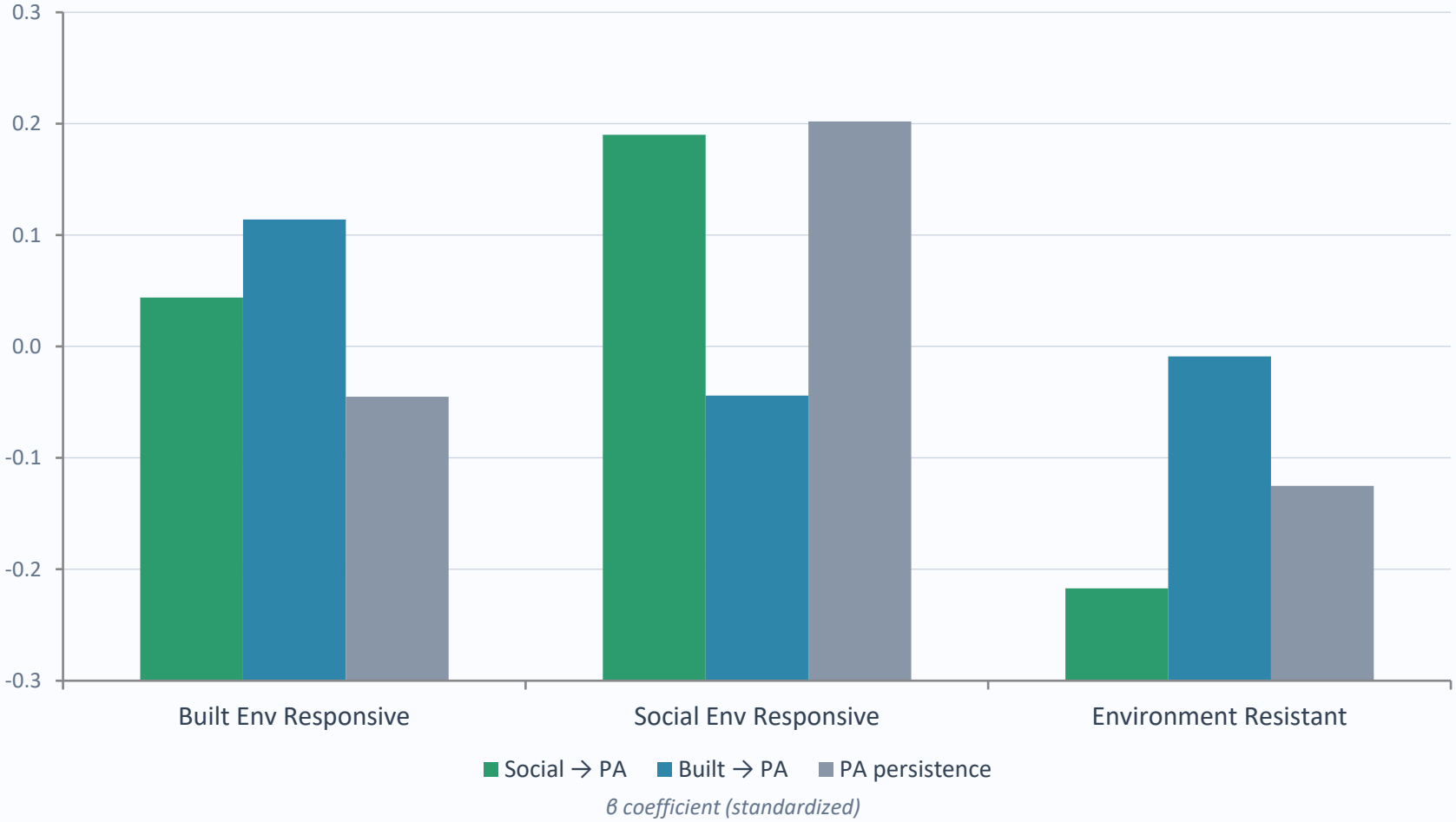
14%

of sample • n = 5

Minimal responsiveness to either social or built environmental factors. Activity decoupled from momentary context.

Validation: 5 of 6 clustering parameters showed significant between-phenotype differences after Bonferroni correction ($p < 0.001$). Dunn index = 0.28

How phenotypes differ in environment responsiveness



Key takeaway

Each phenotype shows a distinct signature.

Built-responsive youth
React most to spaces and surroundings.

Social-responsive youth
Carry momentum and follow peers.

Resistant youth
Show flat or inverse responses across the board.

Values represent person-averaged within-individual correlations between momentary environment perceptions and subsequent MVPA.

Phenotypes can power tailored interventions



Built Environment Responsive

Prompt activity when youth are near accessible, pleasant, safe spaces

EXAMPLES

Park alerts, route suggestions, location-based nudges



Social Environment Responsive

Time prompts around peer presence and active social contexts

EXAMPLES

Group challenges, peer reminders, friend-linked goals



Environment Resistant

Look beyond environment. Address motivation, habit, or other drivers

EXAMPLES

Intrinsic motivation work, habit stacking, alternative levers

Right intervention, right moment, right person.

Where we go from here

Limitations

- Small preliminary sample (N = 36) from a single region
- Phenotypes may be unstable with this many participants and need replication
- Person-specific coefficients are correlational, not causal
- Summer-only sampling limits seasonal comparison

Next Steps

- Replicate with the full cohort (Summers 2026 and 2027, N ≈ 100)
- Add GPS-derived built environment exposures alongside perceptions
- Pilot phenotype-tailored just-in-time adaptive interventions
- Test phenotype stability across seasons and contexts

Thank you



Three takeaways

01 Heterogeneity is real

Youth differ systematically in how their everyday environments shape their physical activity.

02 Three phenotypes

Built-responsive (44%), social-responsive (42%), and environment-resistant (14%) emerged as preliminary clusters.

03 Toward tailored intervention

Digital phenotyping might be able to match the right environmental nudge to the right youth at the right moment.

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