

Why Should I Measure Stress?
**Stress Measurement in Population-
Based Health Studies**

Elissa Epel, PhD & Wendy Berry Mendes, PhD

Department of Psychiatry, UCSF

Outline

1) “Stress” – acute, chronic, toxic: relationship to aging

Multilevel (including exposome)

Lifespan mechanisms (Epel, Mendes, SMN)

Sensitive periods, timing (ELA, daily, chronic)

2) **Measurement of stress**

Network Toolbox

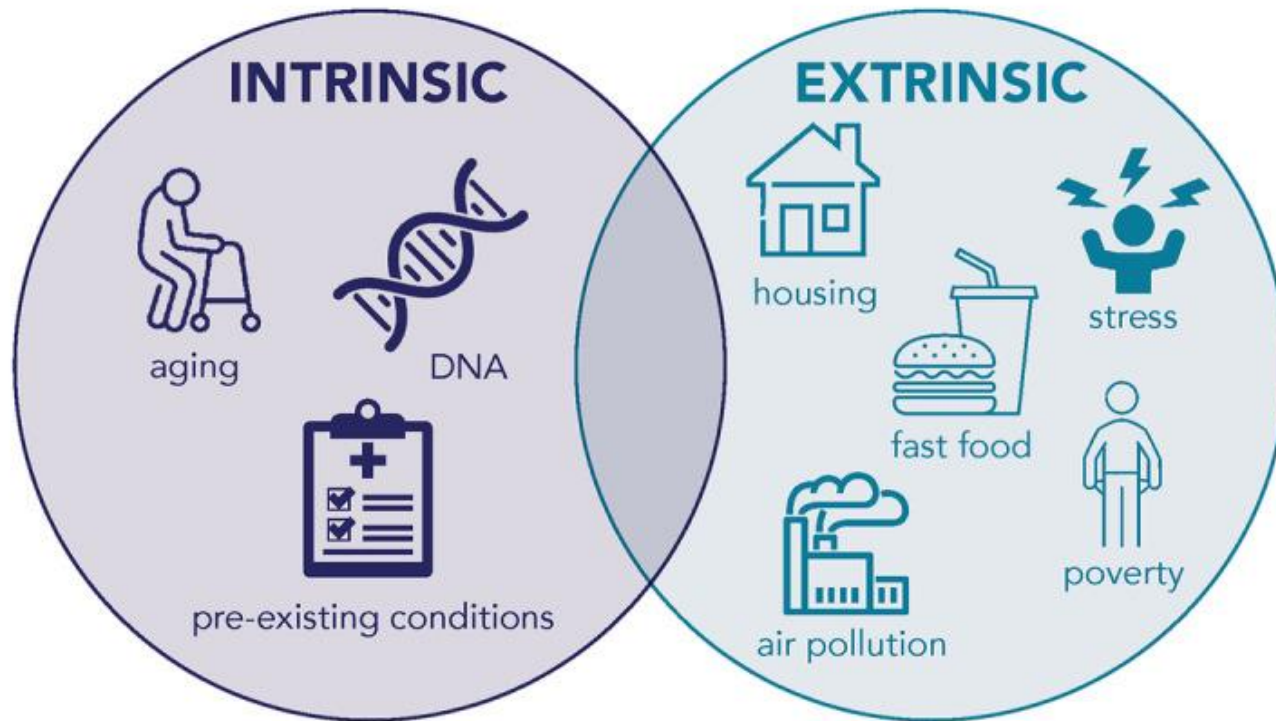
Exemplar: Daily stress appraisal & blood pressure

3) How does stress increase vulnerability to exposures?

When should you measure stress? and How?

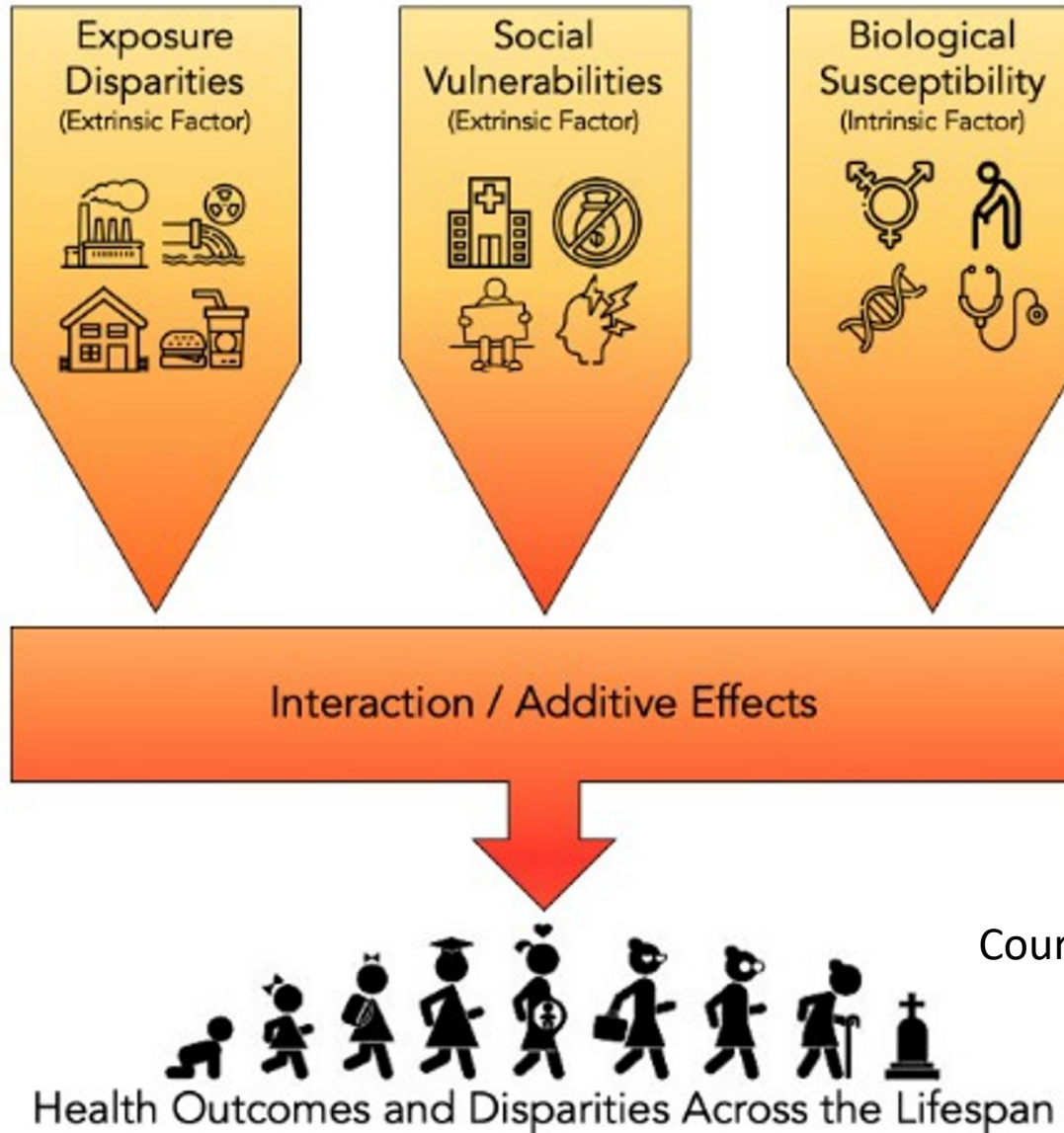
Factors explaining susceptibility to chemical exposure related disease

Intrinsic and Extrinsic Risk Factors for Disease



Default dose-response methods assume a 10-fold difference in response to chemical exposures between average (healthy) and susceptible humans”.
Varshavsky...Woodruff, 2023, Environmental Health

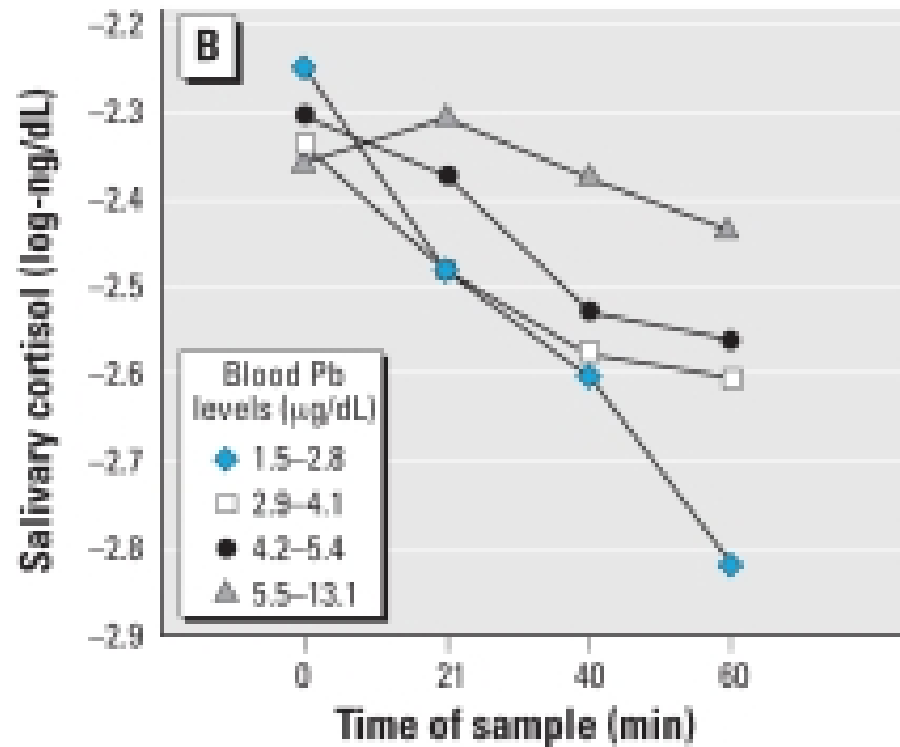
Triple Jeopardy of Social Inequality



Courtesy of Tracey Woodruff



Lead Exposure amplifies Stress Reactivity



(Gump et al, 2009)

Stress as a Potential Modifier of the Impact of Lead Levels on Blood Pressure: The Normative Aging Study

Junette L. Peters,¹ Laura Kubzansky,² Eileen McNeely,¹ Joel Schwartz,¹ Avron Spiro III,³ David Sparrow,³ Robert O. Wright,^{1,4} Huiling Nie,^{1,4} and Howard Hu^{1,4,5}

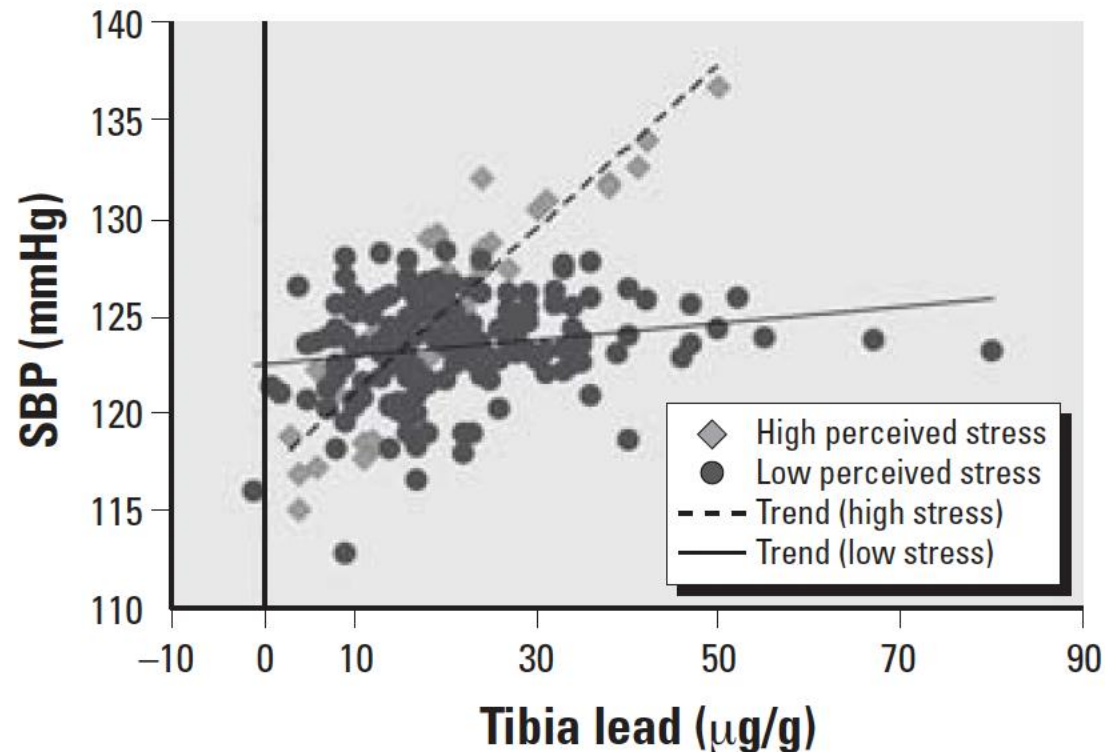
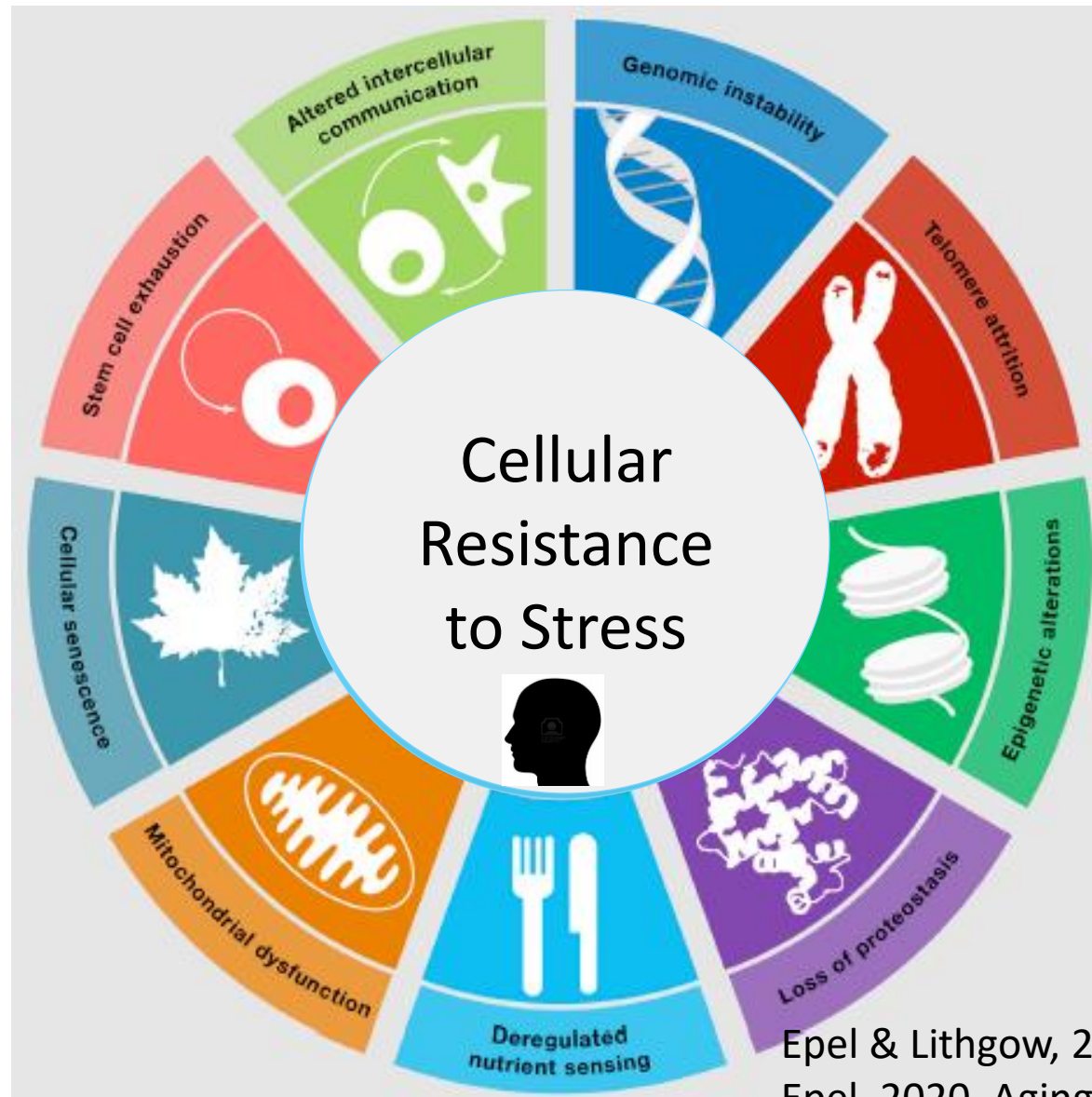


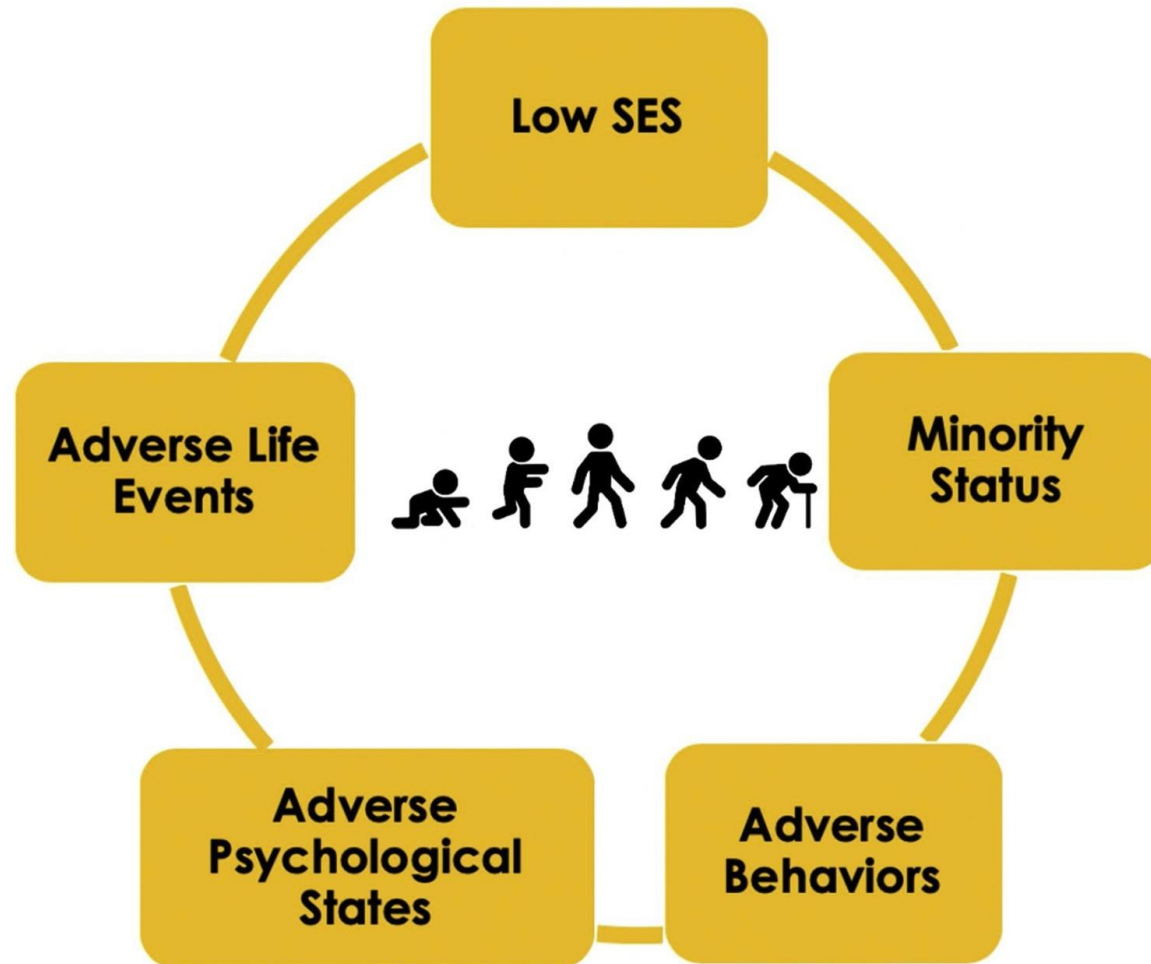
Figure 1. The relationship between tibia lead and estimated SBP for those with high self-reported stress versus those with low self-reported stress.

Stress resilience is core to understanding biological aging

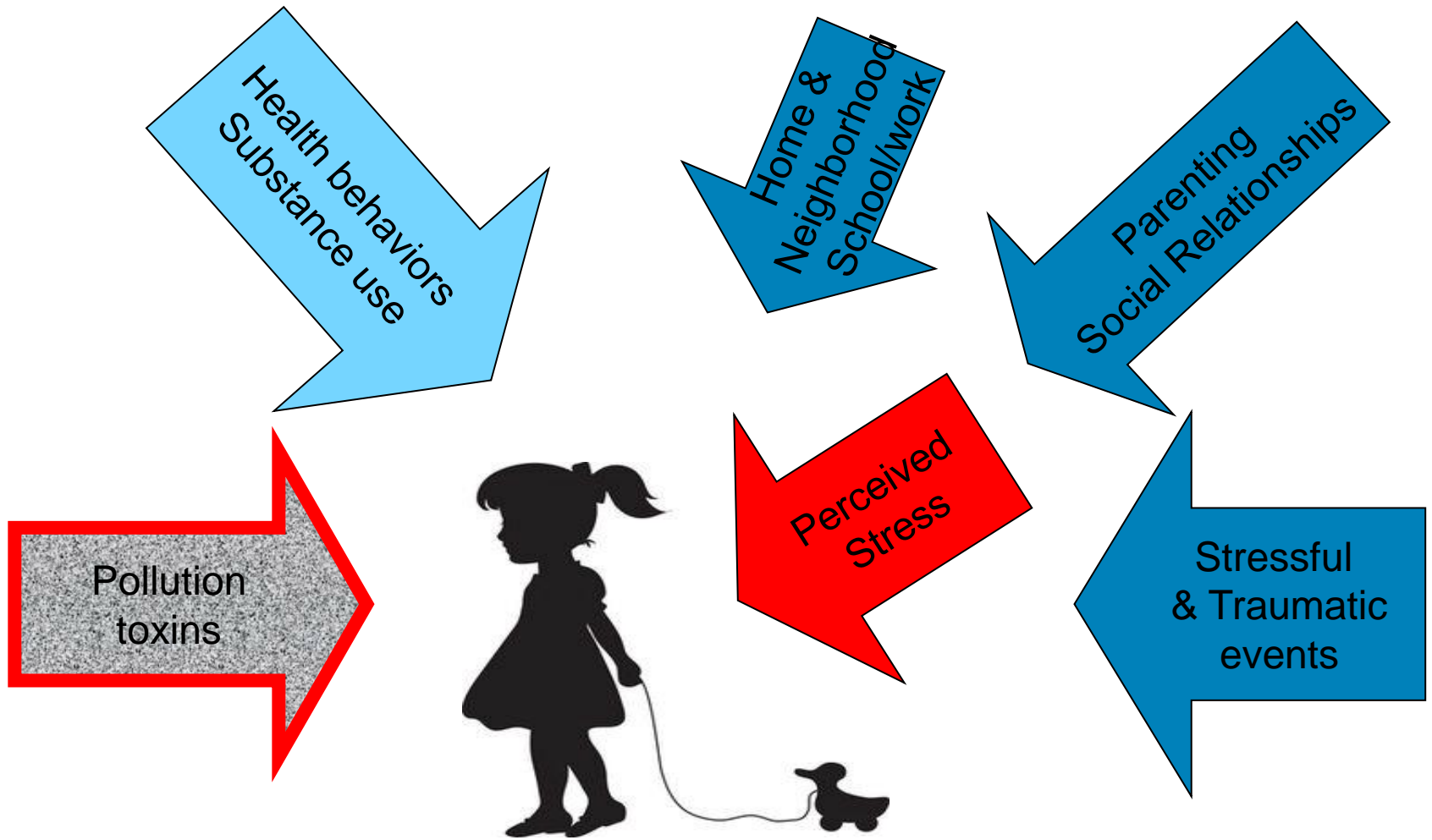


Epel & Lithgow, 2014;
Epel, 2020, Aging Research Reviews

The Social Hallmarks of Aging



The Stress Exposome (partial)



Many biomarkers are associated with these exposures (causal or not)

Multi-level Measurement of “stress”

Tier 1: Exposures: SES, Life events, chronic stressors
retrospective or current



Tier 2: Perceived stress/distress (Self report)

Response to stressors, impact and chronicity
Must be tied closely to the event

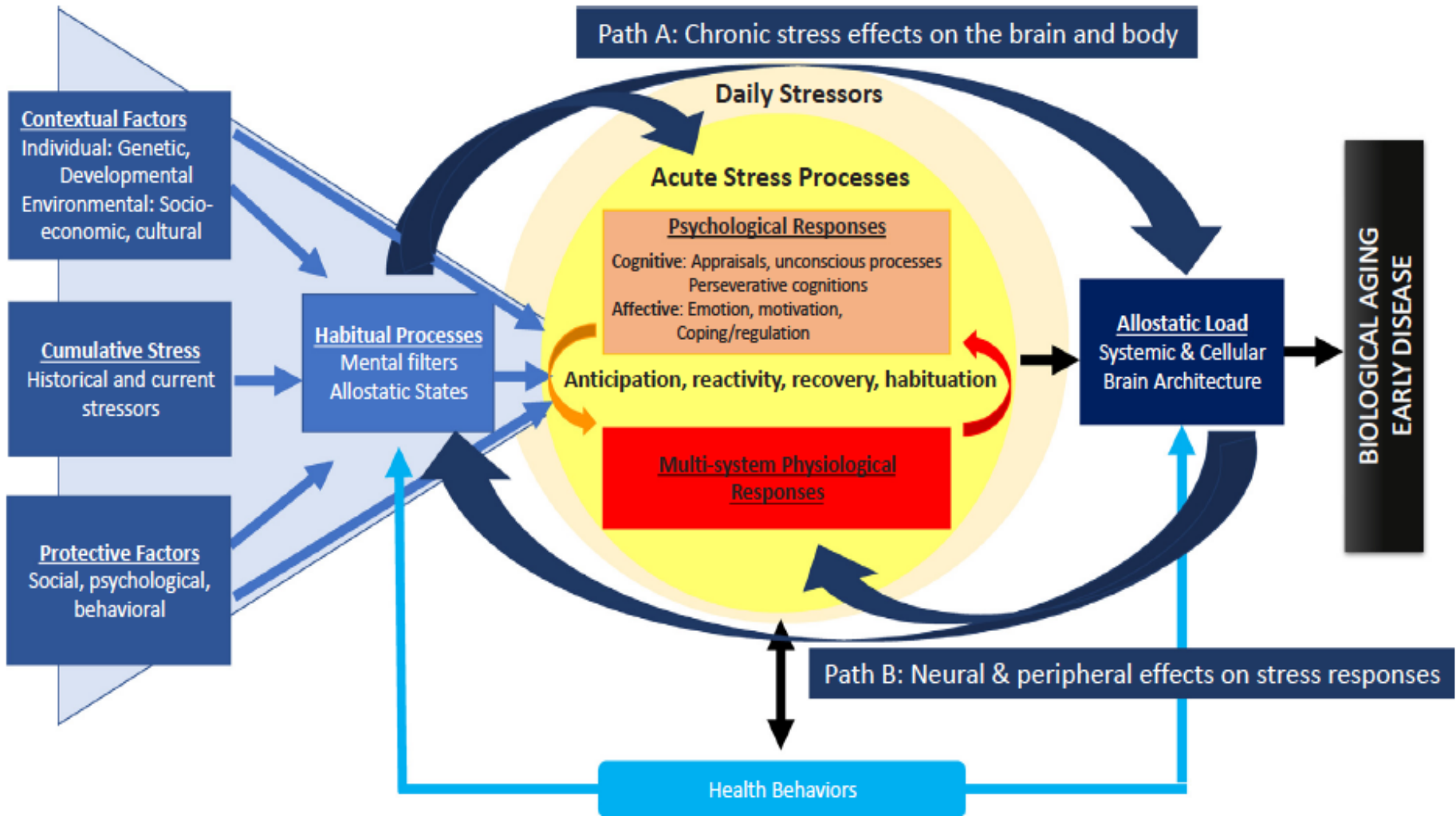


Tier 3: Biological Regulatory systems

Steady state set points (allostatic states)
Reactivity (homeostatic capacity)

Lifespan model of stress & aging

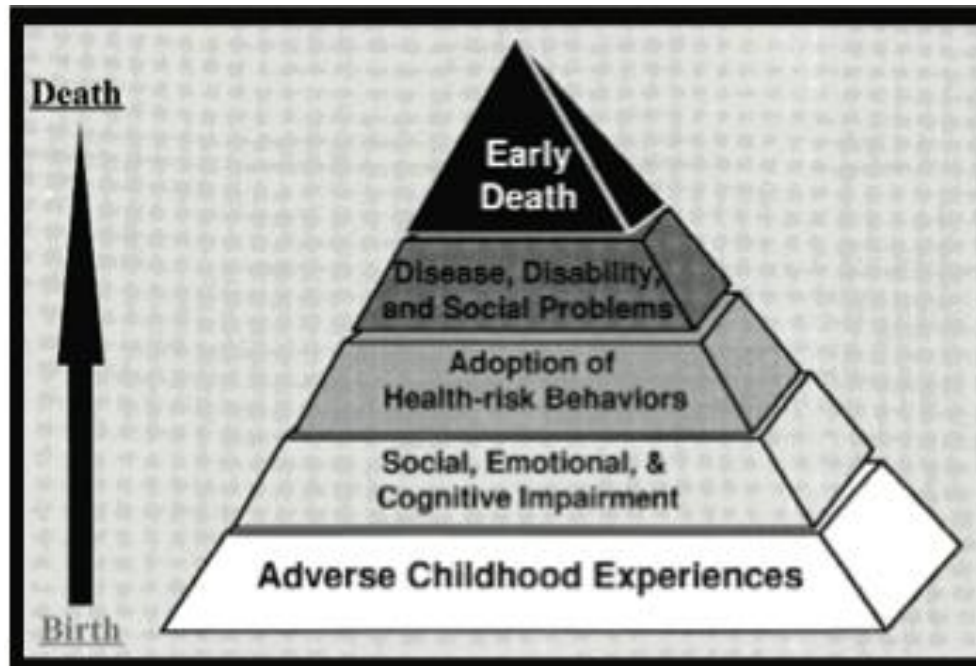
Transdisciplinary model of stress: Integrating contextual, historical, habitual, and acute stress processes



Toxins: Cumulative (lifespan), acute (daily), and persistent risk mechanisms (allostatic load)

Social stress impacts aging biology

(“Hidden Wounds” “Biological Embedding”:
Telomeres, inflammation, epigenetic clock)

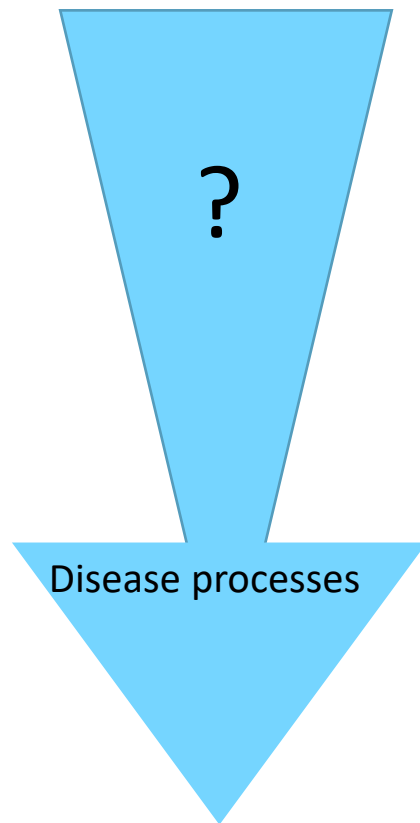


Meta-analyses on telomeres: Hanssen et al, 2017, Lie et al, 2017

Reviews on inflam: Danese et al, 2014; Coelho et al, 2014

Meta-analysis on clock on adult trauma not childhood: Wolf et al, 2018

Impact of stress exposures at life stages:



IN UTERO

CHILDHOOD

ADULTHOOD

OLDER ADULTHOOD

Cumulative but not equal or linear effects!
"Accumulation of risk" and critical periods.
We need to test Interactive effects!

Challenges in stress research

(similar to environmental epidemiology)

- Small relative risks
 - Low ‘penetrance’ bt exposure & phenotype (small effects, and not linear)
 - Individual variation in responses (‘resilience’)
- Multi-exposures / multipathway
 - Interactions (within exposures, and G X E)
 - Lack of specificity of measures of stress, biomarkers
- Exposures vary over time
 - Need to measure sensitive periods (latent effects)
 - Need indices of cumulative risk (wear/tear)

“Telomeres as sentinels of exposures”

- NIEH & NIA Telomere Research Network
- In vivo studies: Exposure to polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), pesticides and metallic elements (ME) with telomere attrition (Houzon et al, 2019)
- Some chemicals (POPS, PFAS) linked to longer TL

Lifespan model of stress, telomere maintenance, and transmission:

Are there different mechanisms over lifespan?



INTERGENERATIONAL TRANSMISSION OF SHORT TELOMERES

Early Childhood:

Early life adversity
Long term effects
(impact stem cell reserves?)

Adolescence:

Common onset of stress-related Psychopathology.
Short telomeres in blood
Low telomerase in hippocampus

Adult

Recurrent Psychopathology
Interactive triad (stress, telomeres, PD)
Less neurogenesis in hippocampus
Multiple tissue telomere shortness



Initial setting of TL in HSC, influenced by parent's genes, parental TL on gametes and maternal prenatal stress

[Home](#) > Resources

TRN Resources

[Lab Protocols](#)

[Reviews & Meta-Analyses](#)

[Study Design & Analysis](#)

[Reporting Guidelines](#)

Considerations for measuring stress:

- “Stress” – can be better operationalized, and well measured prospectively:
 - Exposures & responses (psychological & physiological)
 - Multilevel –social environment, behavioral, subjective (daily and event based)
 - Some stressors can be measured retrospectively (Admin data)
- Requires lifecourse model:
 - Which types/timing of exposures influence aging trajectories?
 - Sensitive periods (birth, early, adolescence, pregnancy)
 - Pregnancy/birth: stressors during pregnancy
 - ELA must be measured: most consistent effects, may be “reversed”
 - Can measure cumulative exposures retrospectively (e.g., STRAIN)
- Biomarkers of aging:
 - Transgenerational, recursive contributions to disparities
 - Markers vs mechanisms? “etiologic pre-disease mechanisms” algorithms vs. single measures

Stress Measures User Guide:

Many also have chemical exposures

<i>Stress Domains</i>	HRS	ELSA	SHARE	TILDA	JSTAR	KLoSA	CHARLS	MHAS	CRELES
Stressful life events & traumas	X*	X*	X*	X*	X	X	X*	X*	
Chronic strains	X	X		X					X
Job strain/stress	X*	X*	X*		X*	X*			
Discrimination	X*	X*		X*					
Social strain and unsupportive relationships	X*	X*	X	X*	X*			X*	X
Loneliness	X*	X*	X*	X*	X	X	X	X	X
Environmental/neighborhood disorder and lack of cohesion	X*	X*	X		X*				

*harmonized variable is available (at least one item is comparable across studies)

- A dataset with harmonized stress variables is freely available with data codebook. Introductory and advanced webinars are also freely available
- 2024 Summer Institute USC/Stress Network



Stress Measurement Toolbox

Purpose of the Stress Measurement Toolbox

The Stress Measurement Toolbox provides a resource of recommendations of stress measures that researchers can use as an information source when deciding which stress measures to include in their studies.

We selected experts to write and review papers that describe what aspects of the construct each measure captures, and highlight unique or important features of each measure. Each entry has been peer-reviewed to create a balanced review of the literature.

Our Toolbox currently includes a range of psychological measures, physiological measures, and measures under development, which can be accessed using the buttons below or by [downloading the full PDF here](#). It should be noted that stress is often associated with levels of or changes in these physiological measures; however, the physiological measures should not themselves be taken to indicate the presence or absence of stress.

Psychological Measures

Physiological Measures



[Home](#)

[About](#)

[Resources](#)

[Toolbox](#)

[Contact Us](#)

Psychological Measures

Appraisals of Acute Stress	Cumulative Life Stress	Financial Strain	Relationship Conflict	Threat Sensitivity
Burnout	Daily Stressors	Major Life Events	Social Isolation	Trait Resilience
Beliefs about Stress	Disasters and Mental Health	Neighborhood Safety	Stigma, Discrimination	Traumatic Life Events
Caregiver Stress	Early Life Stress (events)	Political Stress	Subjective Stress	Unconscious Stress
Climate Stress	Early Life Stress (dimensional)	Pregnancy Stress	Systemic Racism	Work Stress

Measurement of historical stressors is often possible!

PAST STRESSORS:

Pregnancy stressors

Childhood SES

Early life adversity (ELA)

Traumatic life experiences

Major Life Events (current as well)

CURRENT STRESSORS and RESPONSES:

Neighborhood (deprivation, safety & cohesion)

Perceived stress

Financial strain

Social stress (isolation, loneliness, conflict)

Discrimination

Work stress and burnout

SMN Toolbox Update

- <https://www.stressmeasurement.org/measurement-toolbox>
- 7 new measures:
 - Caregiver stress
 - Systemic racism
 - Disaster mental health
 - ELA dimensions
 - Political stress
 - Beliefs about stress
 - Climate stress

Scaling: MyBPLab app



Overview

- 2016 started working on an algorithm to translate information from an infrared light source into blood pressure estimates
- Launched MyBPLab app March 2018 embedded optic sensors on Samsung phones and watches that utilized photoplethysmograph to estimate HR, HRV, and blood pressure
- 3-week long EMA study
- Participants receive 3 notices a day
- Validated the BP algorithm (Gordon & Mendes, 2021, PNAS)
- > 233,000 participants enrolled across two versions of the app (MyBPLab 1.0/2.0)
- > 5 million check-ins
- Participants from more > 100 countries
- Cognitive tasks
- Stress reduction/sleep extension experiments

Stress, Emotions, and Physio in Daily Life

N = 332,716 daily reports from 22,015 participants

Examined in the moment BP and stress and emotion reports

Stress and Blood Pressure

How do daily experiences of **demands** and **resources** affect BP and HR reactivity?

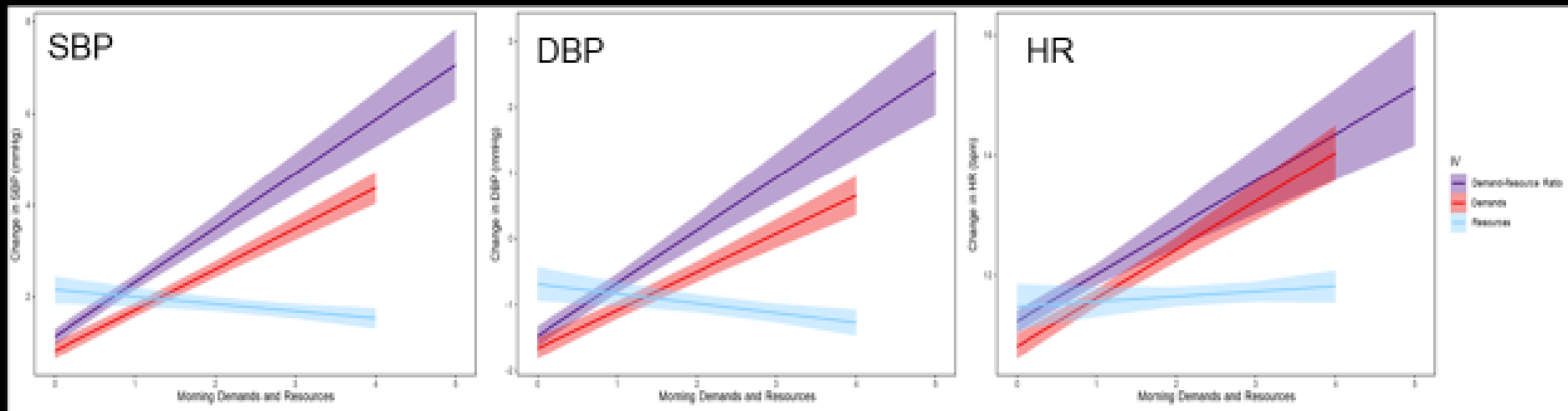
Demands: How overwhelming? How much effort is required? Unpredictability?
Resources: Do you have control over your day? Do you have the abilities/resources/help?

Emotions and Blood Pressure

How do daily **emotional experiences** affect BP and HR reactivity?

Captured valence and arousal in a 2 x 2 grid; Specific emotion labeling followed valence and arousal ratings

Is stress related to daily blood pressure? It is, but not the best predictor



A better predictor of blood pressure in daily life is the combination of stress (how demanding/stressful is your life) relative to your resources (do you have resources to cope)

A photograph of the Golden Gate Bridge in San Francisco, California, taken during a sunset. The sun is low on the horizon, creating a warm, orange and yellow glow that illuminates the bridge's towers and the surrounding sky. The water below is dark, and the bridge's suspension cables are visible against the bright sky. The overall mood is serene and contemplative.

Should I measure Stress ?

What type of stress is most relevant to my outcome?

Can we create a model of risk (and prevention) that incorporates lifespan stress?